01 SOLID FUELS

Sources, winning, properties

08/02443 Application of ^{222}Rn technique to locate subsurface coal heatings in Australian coal mines

Xue, S. *et al. International Journal of Coal Geology*, 2008, 74, (2), 139–144.

Subsurface coal heating poses a significant problem in many coal mines. The identification of the exact location of the heatings that occur in often inaccessible locations several hundred metres deep in goaf areas is a key to allowing effective control measures to be taken. Detailed investigations were carried out to apply the surface-based ^{222}Rn technique to locate subsurface coal heatings in Australia. The results of two field trials indicated that subsurface coal heatings, at depths up to 450 m, lead to isolated ^{222}Rn anomalies on the surface vertically above the heating zones. The geogas microbubble model for ^{222}Rn transport through strata appears to be most in accord with the results of the field trials.

08/02444 Arsenic emission during combustion of high arsenic coals from Southwestern Guizhou, China

Zhao, Y. *et al. Energy Conversion and Management*, 2008, 49, (4), 615–624.

With the aim of better understanding the distribution of arsenic, 144 coal samples were collected from southwestern Guizhou, and the concentrations of arsenic were determined by atomic fluorescence spectrometry and inductively coupled plasma mass spectrometry. The content of arsenic varies from 0.3 ppm to 3.2 wt.%. In most coal samples, the arsenic content was lower than 30 ppm, which was close to a representative value of arsenic concentration of coal in China. Arsenic contents in 37 samples, which were from several small coal mines, were more than 30 ppm, among which only 16 samples were more than 100 ppm, and only a few samples contained more than 1000 ppm, which were very restricted and the coal seams were generally unworkable. Combustion of two kinds of high arsenic coal with and without CaO additive was studied in a bench scale drop tube furnace to understand the partition and emission of arsenic in the process. The PM was size segregated by low pressure impactor into 13 size stages ranging from 9.8 to 0.0281 µm. X-ray fluorescence spectrometry was used to determine the chemical composition of the PM, and inductively coupled plasma atomic emission spectrometry (ICP-AES) was used to determine the arsenic content. A bimodal mode distribution of the PM was formed during coal combustion; the large mode (coarse particle) was formed at 4.0 µm, and the other mode (fine particles) was at about 0.1 µm. A middle mode was gradually obvious in high temperature for both of the two coal combustions, which may have been derived from coagulation and agglomeration of metal elements vapours. More gaseous arsenic was formed in 50% oxygen content than 20% oxygen content. Arsenic in sulfide is easier to vaporize than as arsenate. Along with the increasing temperature from 1100 °C to 1400 °C, the arsenic concentration in PM_1 increased from 0.07 mg/N m^3 to 0.25 mg/N m^3. With the addition of the calcium based sorbent, the arsenic concentration in PM_1 decreases sharply from 0.25 mg/N m^3 to 0.11 mg/N m^3. Thus, the calcium based sorbent is an effective additive to control the emission of arsenic during coal combustion.

08/02445 Effect of mineral matter on coal self-heating rate

Basil Beamish, B. B. and Arisoy, A. *Fuel*, 2008, 87, (1), 125–130.

Adiabatic self-heating tests have been conducted on subbituminous coal cores from the same seam profile, which cover a mineral matter content range of 11.2–71.1%. In all cases the heat release rate does not conform to an Arrhenius kinetic model, but can best be described by a third-order polynomial. Assessment of the theoretical heat sink effect of the mineral matter in each of the tests reveals that the coal is less reactive than predicted using a simple energy conservation equation. There is an additional effect of the mineral matter in these cases that cannot be explained by heat sink alone. The disseminated mineral matter in the coal is therefore inhibiting the oxidation reaction due to physicochemical effects.

08/02446 Investigation on interior moisture distribution inducing dielectric anisotropy of coals

Wang, Q. *et al. Fuel Processing Technology*, 2008, 89, (6), 633–641.

Dielectric anisotropy phenomenon of coal was detectable by many dielectric measurements. The paper presented that it was attributed to coal interior moisture distribution. A new model describing interior moisture distribution was developed basing on microstructure observation of coal. In the model, coal interior moisture distribution was analysed and simulated numerically, the relationship between interior moisture distribution and coal dielectric property was constructed, the character of the permittivity varying with moisture content had also been studied and coal dielectric anisotropy was deduced. Corresponding experiment results were well satisfied with the model analysis, demonstrating that the interior moisture content could cause coal dielectric anisotropy.

08/02447 Mineralogy and geochemistry of boehmite-rich coals: new insights from the Haerwusu Surface Mine, Jungar Coalfield, Inner Mongolia, China

Dai, S. *et al. International Journal of Coal Geology*, 2008, 74, (3–4), 185–202.

Boehmite-rich coal of Pennsylvanian age was discovered earlier at the Heidaigou Surface Mine, Jungar Coalfield, Inner Mongolia, China. This paper reports new results on 29 bench samples of the no. 6 coal from a drill core from the adjacent Haerwusu Surface Mine, and provides new insights into the origin of the minerals and elements present. The results show that the proportion of inertinite in the no. 6 coal is higher than in other Late Paleozoic coals in northern China. Based on mineral proportions (boehmite to kaolinite ratio) and major element concentrations in the coal benches of the drill core, the no. 6 coal may be divided into five sections (I–V). Major minerals in Sections I and V are kaolinite. Sections II and IV are mainly kaolinite with a trace of boehmite, and Section III is high in boehmite. The boehmite is derived from bauxite in the weathered surface (Benxi Formation) in the sediment-source region. The no. 6 coal is rich in Al_2O_3 (8.89%), TiO_2 (0.47%), Li (116 µg/g), F (286 µg/g), Ga (18 µg/g), Se (6.1 µg/g), Sr (350 µg/g), Zr (268 µg/g), REEs (172 µg/g), Pb (30 µg/g), and Th (17 µg/g). The elements are classified into five associations by cluster analysis, i.e. Groups A, B, C, D, and E. Group A (ash–SiO_2–Al_2O_3–Na_2O–Li) and Group B (REE–Sc–In–Y–K_2O–Rb–Zr–Hf–Cs–U–P_2O_5–Sr–Ba–Ge) are strongly correlated with ash yield and mainly have an inorganic affinity. The elements that are negatively or less strongly correlated with ash yield (with exceptions of Fe_2O_3, Be, V, and Ni) are grouped in the remaining three associations: Group C, Se–Pb–Hg–Th–TiO_2–Bi–Nb–Ta–Cd–Sn; Group D, Co–Mo–Tl–Be–Ni–Sb–MgO–Re–Ga–W–Zn–V–Cr–F–Cu; and Group E, S–As–CaO–MnO–Fe_2O_3. Aluminum is mainly distributed in boehmite, followed by kaolinite. The high correlation coefficients of the Li–ash, Li–Al_2O_3, and Li–SiO_2 pairs indicate that Li is related to the aluminosilicates in the coal. The boehmite-rich coal is high in gallium and F, which occur in boehmite and the organic matter. Selenium and Pb are mainly in epigenetic clausthalite fillings in fractures. The abundant rare earth elements in the coal benches were supplied from two sources: the bauxite on the weathered surface of the Benxi Formation and from adjacent partings by groundwater leaching during diagenesis. The light rare earth elements (LREEs) are more easily leached from the partings and incorporated into the organic matter than the heavy REEs, leading to a higher ratio of LREEs to HREEs in the coal benches than in the overlying partings.

08/02448 Oxygen groups in coals and alginite-rich kerogen revisited

Petersen, H. I. *et al. International Journal of Coal Geology*, 2008, 74, (2), 93–113.

Detailed Fourier transform infrared spectroscopy (FTIR), chemical oxidation and reduction, and multivariate regression analysis have been applied to gain insight into the relative proportions and types of oxygen functional groups in coals of varying rank and in alginite-rich organic matter in oil shales and marine shale. FTIR spectra of demineralized and non-demineralized coals with a vitrinite reflectance below $\sim 0.4\% R_o$ revealed that the spectra are significantly different in the carbonyl region, probably due to the configuration of weak conjugated oxygen bonds into a more rigid form during demineralization. In coals and lignin, the relative FTIR response from oxygen groups occurs in the order hydroxyl ≥ ether > ketone/ester > carboxyl > quinone, where ester groups are related to cutinite and sporinite. A pronounced decrease in oxygen content occurs from ~ 0.43–$0.50\% R_o$, but the oxygen groups show different evolutionary trends during initial thermal maturation: (i) carboxyl group absorption increases significantly up to lignite/subbituminous C rank, followed by a rapid decrease and disappearance at $\sim 0.45\% R_o$, (ii) ketone (carbonyl) group absorption is prominent at maturities $< 0.45\% R_o$, but at higher maturities the response declines gradually, (iii) ether group absorption increases to a maximum at ~ 0.45–$0.50\% R_o$, from where it decreases gradually, (iv) at atomic O/C ratios > 0.2 (approximately $< 0.45\% R_o$) hydroxyl group (principally phenolic) absorption is highly variable, but at increasing thermal maturity significant dehydroxylation occurs. Elimination of oxygen groups in the coaly organic matter thus occurs in the order quinone, carboxyl, ketone/ester, hydroxyl and ether. Both ether and hydroxyl are still present at an O/C ratio of 0.05. Oxygen in the alginite-dominated kerogen of the shales is entirely bound as ether, carbonyl (mainly ester) and hydroxyl. The presence of ether agrees with the dominant role of ether bonds cross-linking long-chain *n*-alkanes in algaenan. Hydroxyl may be related to phenolic units in for example

Botryococcus algae. The relative FTIR response from oxygen groups in kukersite is ether > carbonyl (ketone) > hydroxyl, which generally reflects the structural models proposed for kukersite. Oxygen groups in the coals can overall be correlated to the least-altered huminite macerals textinite, texto-ulminite, and densinite, or to the associated cutinite and sporinite, whereas the variation of the oxygen group composition in the studied shales seems to be controlled by thermal maturity. Hydrogen Index (HI) values of chemically oxidized and/or reduced coal samples do not provide an unequivocal answer to whether HI values of immature coals are underestimated. Incorporation of carboxyl groups into the original coal kerogen does not produce a more immature coal manifested by decreased HI values.

08/02449 Single-coal-particle combustion in O_2/N_2 and O_2/CO_2 environments

Bejarano, P. A. and Levendis, Y. A. *Combustion and Flame*, 2008, 153, (1–2), 270–287.

A fundamental investigation has been conducted on the combustion of single particles of a bituminous coal (45–53, 75–90, and 150–180 μm), of a lignite coal (45–53 and 75–90 μm), and of spherical and monodisperse synthetic chars (43 μm) at increasing O_2 mole fractions in either N_2 or CO_2 balance gases. The synthetic particles were used to facilitate the observation of combustion phenomena with minimum distractions from particle-to-particle variabilities. The laboratory setup consisted of a drop-tube furnace operated at temperatures of 1400 and 1600 K. A calibrated three-colour pyrometer, interfaced with the furnace, recorded luminous particle temperature–time profiles. Experimental results revealed that coal particles burned at higher mean temperatures and shorter combustion times in O_2/N_2 than in O_2/CO_2 environments at analogous oxygen mole fractions. In the case of the bituminous coal used herein and for the experimental combustion conditions tested, measured volatile and char temperatures as in air (21% O_2) were attained with an oxygen content in the CO_2 mixtures in the neighbourhood of 30%. Bituminous coal volatile and char burnout times comparable to those in air (21% O_2) were attained with oxygen content in the CO_2 mixtures in the range of 30–35%. In the case of the lignite coal burned, the corresponding differences in oxygen mole fractions, which result in similar particle temperatures and burnout times in the two different gas mixtures, were less pronounced.

08/02450 Supercritical gas sorption on moist coals

Day, S. *et al. International Journal of Coal Geology*, 2008, 74, (3–4), 185–202.

The effect of moisture on the CO_2 and CH_4 sorption capacity of three bituminous coals from Australia and China was investigated at 55 °C and at pressures up to 20 MPa. A gravimetric apparatus was used to measure the gas adsorption isotherms of coal with moisture contents ranging from 0 to about 8%. A modified Dubinin–Radushkevich (DR) adsorption model was found to fit the experimental data under all conditions. Moisture adsorption isotherms of these coals were measured at 21 °C. The Guggenheim–Anderson–de Boer model was capable of accurately representing the moisture isotherms over the full range of relative pressures. Moist coal had a significantly lower maximum sorption capacity for both CO_2 and CH_4 than dry coal. However, the extent to which the capacity was reduced was dependent upon the rank of the coal. Higher rank coals were less affected by the presence of moisture than low rank coals. All coals exhibited a certain moisture content beyond which further moisture did not affect the sorption capacity. This limiting moisture content was dependent on the rank of the coal and the sorbate gas and, for these coals, corresponded approximately to the equilibrium moisture content that would be attained by exposing the coal to about 40–80% relative humidity. The experimental results indicate that the loss of sorption capacity by the coal in the presence of water can be simply explained by volumetric displacement of the CO_2 and CH_4 by the water. Below the limiting moisture content, the CO_2 sorption capacity reduced by about 7.3 $kg\,t^{-1}$ for each 1% increase in moisture. For CH_4, sorption capacity was reduced by about 1.8 $kg\,t^{-1}$ for each 1% increase in moisture. The heat of sorption calculated from the DR model decreased slightly on addition of moisture. One explanation is that water is preferentially attracted to high energy adsorption sites (that have high energy by virtue of their electrostatic nature), expelling CO_2 and CH_4 molecules.

08/02451 The use of fractal analysis in the textural characterization of coals

Mahamud, M. M. and Novo, M. F. *Fuel*, 2008, 87, (2), 222–231.

The materials studied were four bituminous coals as well as the corresponding coal samples oxidized in air at 543 K for different periods of time. The method proposed by Friesen and Mikula, the procedure of Neimark and the methodology of Zhang and Li were successfully employed to analyse mercury porosimetry data from a fractal perspective. Fractal dimensions as well as fractal profiles are sensitive to oxidation treatment, being useful to follow the changes undergone by the coal samples. The evolution of the fractal dimension of coals with oxidation is determined by a balance between two main mechanisms of pore development: the oxidation of the pore surface itself that tends to lower the fractal dimension and the access of mercury to previously non-accessible regions that tends to increase this dimension.

Preparation

08/02452 Ash chemistry and mineralogy of an Indonesian coal during combustion: part 1 drop-tube observations

Vuthaluru, H. B. and French, D. *Fuel Processing Technology*, 2008, 89, (6), 595–607.

The paper reports a systematic and comprehensive laboratory investigation into the ash chemistry and mineralogical changes undergone by a low-rank Indonesian coal during combustion. Combustion experiments conducted in a drop-tube furnace included ash formation experiments (using cyclone and filter arrangement) under closely controlled conditions in the range of 1200–1400 °C and deposition experiments at a probe temperature of 750 °C. Tests conducted with raw coal, coal/additive mixtures and washed coal indicated significant changes in ash characteristics. Of the ash formation and deposit samples examined, the raw coal + bauxite showed the lowest glass content and high contents of corundum indicating low ash deposition propensities. When compared to the ash formation samples, the deposit samples showed even significantly lower glass contents and were enriched in quartz. With the exception of the raw coal + bauxite sample, all are characterized by high silica and iron and moderate aluminium contents. In contrast, the raw coal + bauxite sample have low silica and much higher alumina contents which is in agreement with XRD observations. QEMSCAN^{TM} results showed that the ash particles are sparsely distributed suggesting lack of a deposit initiation layer. Experimental observations suggest that the use of raw coal with bauxite would appear to offer the best performance with respect to handling ash-related issues. Present findings are of practical significance to power utilities employing Indonesian coal as there is no comprehensive work reported in the literature on ash chemistry and mineralogy of such coals.

08/02453 Ash chemistry and mineralogy of an Indonesian coal during combustion: part II – pilot scale observations

Vuthaluru, H. B. and French, D. *Fuel Processing Technology*, 2008, 89, (6), 608–621.

This paper reports on combustion experiments carried out in a pilot scale furnace as a follow-up to research previously carried out using a drop-tube furnace to investigate the combustion behaviour of an Indonesian coal, in particular the effects of additives on ash chemistry, mineralogy and ash deposit formation. Combustion experiments were carried out in a pilot scale furnace to test the effectiveness of bauxite addition in reducing ash build-up. Samples collected from deposits on the slagging panels and fouling probe tubes, electrostatic precipitator fly ash, the furnace ash and tunnel ash were fully characterized using various analytical techniques. Experimental results substantiated earlier drop-tube observations suggesting that the use of raw coal with an addition of 3 wt.% bauxite would appear to offer the best performance with respect to slagging and fouling propensity in comparison to use of the raw coal alone. Observations on the reduction in glass content resulting from the addition of bauxite during PSF test runs support the earlier findings of the drop-tube tests. The reduction in glass content found in the slagging panel and fouling probe samples is comparable to that found in ash formation experiments conducted at 1400 °C despite the observed differences in mineralogy. Although deposits are still likely to form as indicated by the PSF runs they appear to be more friable and hence amenable to removal by conventional methods such as frequent soot blowing. These findings demonstrate how the results of laboratory experiments can be combined with those of pilot scale trials to provide data for full-scale trials on the effects of additives in the remediation of ash problems associated with the firing low-rank coals.

08/02454 Influence of rank and macerals on the burnout behaviour of pulverized Indian coal

Choudhury, N. *et al. International Journal of Coal Geology*, 2008, 74, (2), 145–153.

The combustion behaviour of coal is significantly influenced by its rank and maceral and microlithotype compositions. Different macerals, due to their distinct and unique physical properties and chemical makeup, have different burning characteristics. This paper deals with the burning behaviour of coals of Indian origin by thermogravimetric analysis (TGA) and in drop tube furnace (DTF) with particular emphasis on the role of macerals and their associations. Four coals of different rank and petrographic makeup, along with their two density fractions, with enriched vitrinite and inertinites, respectively, were studied in both TGA and DTF. The burnout behaviour was estimated from the chemical analyses of the char samples collected from the DTF. The burning characteristics of one of the coals deviate from the trend expected with the variations of rank. The behaviour of the density fractions in DTF was found to be different from that observed in TGA analyses. An attempt has been made to correlate the burnout with the petrographic macerals and microlithotypes present in the coals. The morphology of the residual chars indicates the contributions of the inertinites towards the formation of cenospheres and network types of reactive chars. The superior burning behaviour of the higher density inertinite-rich fractions over the raw coals and also some vitrinite-rich fractions indicate the better reactivity of the inertinites towards combustion.

Economics, business, marketing, policy

08/02455 An econometrics view of worldwide fossil fuel consumption and the role of US

Shafiee, S. and Topal, E. *Energy Policy*, 2008, 36, (2), 775–786.

Crude oil, coal and gas, known as fossil fuels, play a crucial role in the global economy. This paper proposes new econometrics modelling to demonstrate the trend of fossil fuels consumption. The main variables affecting consumption trends are: world reserves, the price of fossil fuels, US production and US net imports. All variables have been analysed individually for more than half a century. The research found that while the consumption of fossil fuels worldwide has increased trends in the US production and net imports have been dependent on the type of fossil fuels. Most of the US coal and gas production has been for domestic use, which is why it does not have a strong influence on worldwide fossil fuel prices. Moreover, the reserves of fossil fuels have not shown any diminution during the last couple of decades and predictions that they were about to run out are not substantiated. The nominal and real price of fossil fuels was found to change depending on the type. Finally, estimates of three econometric models for the consumption of fossil fuels from 1949 to 2006 are presented which identify the effects of significant variables.

08/02456 Evaluating community investments in the mining sector using multi-criteria decision analysis to integrate SIA with business planning

Esteves, A. M. *Environmental Impact Assessment Review*, 2008, 28, (4–5), 338–348.

Gaining senior management's commitment to long-term social development projects, which are characterised by uncertainty and complexity, is made easier if projects are shown to benefit the site's strategic goals. However, even though the business case for community investment may have been accepted at a general level, as a strategy for competitive differentiation, risk mitigation and a desire to deliver – and to be seen to deliver – a 'net benefit' to affected communities, mining operations are still faced with implementation challenges. Case study research on mining companies, including interviews with social investment decision-makers, has assisted in developing the Social Investment Decision Analysis Tool (SIDAT), a decision model for evaluating social projects in order to create value for both the company and the community. Multi-criteria decision analysis techniques integrating business planning processes with social impact assessment have proved useful in assisting mining companies think beyond the traditional drivers (i.e. seeking access to required lands and peaceful relations with neighbours), to broader issues of how they can meet their business goals and contribute to sustainable development in the regions in which they operate.

08/02457 Lignite industry in Greece within a world context: mining, energy supply and environment

Kavouridis, K. *Energy Policy*, 2008, 36, (4), 1257–1272.

Today coal covers 38% of global production and roughly 30% of the EU-25 power output. In 2005 domestic lignite with a share of 60.5% in power generation and accounting about 30% of primary energy consumption is currently the most important indigenous fuel of Greece. Greece, mining 70 Mt annually, is the second lignite producer in the EU and fourth in the world. Approximately 97% of the lignite used to supply the existing lignite-fired power plants of Greece is mined by Public Power Corporation S.A. (PPC). Lignite as the base load fuel gives a competitive strength in PPC's and Greece's fuel mix. Due to lignite consumer prices in Greece are significantly below those in other comparable markets in EU-15. Extraction of lignite has a very long tradition. Significant achievements and large experience which has been gained during many years of mining operations place Greek lignite-mining industry in the leading position in Europe. The paper presents current state of Greek lignite industry, including operating mines, volume of production and other important production indicators as well as improvements in labor productivity and good results in industrial safety. The future of coal and specifically of Greek lignite will be crucially determined by environmentally compatible, i.e. low-CO_2 generation of electricity. Investment in modernization and renewal of the power plant fleet are the key to securing electricity supply and progress in preventing climate change.

08/02458 Modelling adaptation of the coal industry to sustainability conditions

Suwala, W. *Energy*, 2008, 33, (7), 1015–1026.

Fossil fuels still constitute an important source of energy in the world, but they need to comply with more strict environmental requirements. The coal industry, the basic primary energy supplier to the Polish economy, not only faces new environmental regulations but also restructuring and changes in the industry's organizational structure. The issues of primary importance are the medium and long-term prospects of achieving a suitable quantity and quality of coal supplied, as well as suitable costs. The structure of power generation needs to adjust to emissions limits with given fuel supplies. The paper discusses the construction of a coal supply balancing system which has been developed and applied as a decision support for rational planning of the development of the Polish coal industry. It consists of two linked groups of models: coal supply and coal balancing. Such a structure allows it to respond to the problems emerging for the most part from new environmental regulations, and to select policies that will lead to sustainability in the industry.

08/02459 Neo-mineral formation during artificial coalification of low-ash – mineral free-peat material from tropical Malaysia-potential explanation for low ash coals

Wüst, R. *et al. International Journal of Coal Geology*, 2008, 74, (2), 114–122.

Abundant coal deposits have very low inorganic contents (ash yield; <2%) and hence are almost ash-free. Inexplicable to date is that the precursor of coal, modern peat deposits, almost nowhere have such low ash yields as a result of both the inorganic mineral and biogenic phytolith contents. However, despite the common occurrence of phytoliths in modern peats, they are invariably absent in coals. It has thus been hypothesized by some investigators that modern environments are not ideal analogues for the formation of low ash coal deposits. Here, new evidence is presented to suggest that mineral diagenesis during coalification can transform biogenic inorganics to new minerals and that a substantial component of these new minerals could be removed in solution during expulsion of moisture with coalification resulting in low ash precursors of coal. This study presents results from artificial coalification experiments of modern tropical forest peat material with ash yields between 2–4.3 wt.%. The inorganic material of the peat consists almost exclusively of Al–Si-and Si-rich phytoliths and other bioliths; no other inorganic mineral matter is present. Compressed pellets of dried peat were deformed in a Griggs constant strain rate apparatus at a constant confining pressure of 5 kb and constant strain rate of $10^{-5}\,s^{-1}$ at variable temperatures from 350 °C to 550 °C. The samples, exposed to artificial coalification processes, were then analysed by SEM, EDS, and XRD for semi-quantitative chemical analyses. The deformed material showed a lack of any biogenic silica and Al–Si-phytoliths, but contained neoformed idiomorphic quartz crystals and clays. It is concluded that modern peat forming environments that have low-ash peats containing biogenic silica and other biogenic Al–Si-material can represent precursors of very low-ash coal deposits. The experiments illustrate that during coalification, it is likely all or almost all biogenic material is transformed into new minerals, mainly quartz and clay minerals, such as kaolinite. Because natural systems are not confined to the same degree as the experiments, it is likely that part or all of the inorganic fraction migrates in solutions out of the peat or coal seam with available fluids, resulting in an almost ash-free coal deposit.

08/02460 Non-impact of particle size distribution on power generation at a pulverized coal power plant burning low rank Alaska coal

Malav, D. *et al. Fuel Processing Technology*, 2008, 89, (5), 499–502.

This paper details two combustion tests that were conducted in a pulverized coal power plant in Healy, Alaska, on low rank high volatile content Alaska coal. The intent of the tests was to determine if combustion suffered when coal was ground to a coarser particle size distribution (PSD) than current standards (70% passing −200 mesh or 74 microns, for bituminous coal). Prior studies had indicated that the higher reactivity of Alaska coal would make up for any loss of combustion due to large particle sizes. The first test (the default power plant setting at that time) had a PSD of 48.8% passing −200 mesh, while the second test was coarser than that, with only 41.8% passing −200 mesh. The samples for PSD were taken using ASTM procedures. The two tests burned similar BTUs and had similar combustion. Combustion was measured indirectly through steam and megawatt generation.

08/02461 Solid fuels in chemical-looping combustion

Leion, H. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (2), 180–193.

The feasibility of using a number of different solid fuels in chemical-looping combustion (CLC) has been investigated. A laboratory fluidized bed reactor system for solid fuel, simulating a CLC system by exposing the sample to alternating reducing and oxidizing conditions, was used. In each reducing phase 0.2 g of fuel in the size range 180–250 µm was added to the reactor containing 40 g oxygen carrier of size 125–180 µm. Two different oxygen carriers were tested, a synthetic particle of 60% active material of Fe_2O_3 and 40% $MgAl_2O_4$ and a particle consisting of the natural mineral ilmenite. Effect of steam content in the fluidizing gas of the reactor was investigated as well as effect of temperature. A number of experiments were also made to investigate the rate of conversion of the different fuels in a CLC system. A high dependency on steam content in the fluidizing gas as well as temperature was shown. The fraction of volatiles in the fuel was also found to be important. Furthermore the presence of an oxygen carrier was shown to enhance the conversion rate of the intermediate gasification reaction. At 950 °C and with 50% steam the time needed to achieve 95% conversion of fuel particles with a diameter of 0.125–0.18 mm ranged between 4 and 15 min depending on the fuel, while 80% conversion was reached within 2–10 min. In almost all cases the synthetic Fe_2O_3 particle with 40% $MgAl_2O_4$ and the mineral ilmenite showed similar results with the different fuels.

Derived solid fuels

08/02462 An approach to blast furnace coke quality prediction

Álvarez, R. *et al. Fuel*, 2007, 86, (14), 2159–2166.

Although coke cold drum mechanical strength has historically been the most relevant coke quality parameter, currently coke reactivity and post-reaction strength (CRI/CSR) are the most important parameters used to assess blast-furnace coke quality. Many models of coke quality prediction have been proposed, most of which are based on coal characteristics and limited to the same coal geographic origin, but as yet there is no universally applicable prediction formula. The present work describes a simple model of coke CRI/CSR prediction based on the assumption that the CSR of a coke produced from a blend of coals can be predicted from the CSR obtained from the cokes of the individual coals through the application of the additivity law. The additivity law was also applied to the coke cold mechanical strength indices derived from the Irsid test, which are widely employed by the European coke industry as complementary coke quality indicators.

08/02463 Analysis of pulsating electric signals generated in gas–solids pipe flow

Matsusaka, S. *et al. Chemical Engineering Science*, 2008, 63, (5), 1353–1060.

In gas–solids pipe flow, particles are electrostatically charged as a result of repeated impacts on the inner walls. When a section of the pipe made of metal is electrically isolated and the charge leakage to the ground is monitored, pulsating electric signals are detected. In the present work, these signals have been studied both experimentally and theoretically. Micrometre-sized alumina particles were dispersed through an ejector and continuously transported in dilute phase. The pipes used were 6 mm in inner diameter, and a pre-charging pipe and detection pipes were installed in the particle transport system. The pulsating electric signals were found to vary in a wide range from positive to negative. The variation of the electric signals was attributed to two electrostatic phenomena: (i) the induced current caused by the transport of a cloud of charged particles and (ii) the particle charging caused by repeated impacts on the inner wall. Based on analyses of these phenomena, the total charge, transferred charge, and particle concentration of the cloud can be evaluated. Furthermore, the average velocity of the cloud flowing in the pipe can be obtained from the time interval between peak signals measured with a detection pipe or using a two-detection pipe system based on the correlation method.

08/02464 Modeling of mass transfer and thermal cracking during the coking of Athabasca residue

Radmanesh, R. *et al. Chemical Engineering Science*, 2008, 63, (6), 1683–1691.

The kinetics of thermal cracking of films of vacuum residue from Athabasca bitumen in the temperature range of 457–530° was modelled with liquid-phase mass transfer, reaction-dependent fluid properties, and coke formation by reaction of cracked products in the liquid phase. Previous investigations on the thermal cracking of vacuum residue in thin films showed that at low film thickness ($\sim 20 \pm 2$ µm) the coke yield was insensitive to the temperature and heating rate for thin films of bitumen. The coke yield increased with the thickness of the initial film, in the range from 20 to 80 µm (+2 µm). At the same time, the viscosity of the reacting liquid increased rapidly with time, which would slow down the diffusion of products inside the film. This coupling of transport and reaction would enhance the formation of coke by increasing the rate of recombination reactions. The concept of intrinsic coke is used in a new kinetic model to account for the minimum observed coke formation in thin films. With increasing film thickness, the increasing yield of extrinsic coke is modelled through the change in fluid properties as a function of extent of reaction, which reduces the rate of diffusion in the reacting liquid phase. The model was able to properly account for the insensitivity of coke yield in thin films to reaction temperature and the dependence of coke yield on the thickness of the liquid film.

08/02465 Numerical study on the spatial distribution of energy release during char combustion

Gu, M. *et al. Applied Energy*, 2008, 85, (11), 1060–1070.

The energy distribution coefficient (X_c), the fraction of the total heat of reaction released at the char surface during combustion of char particles, was studied using the improved moving flame front model. The energy distribution coefficient (X_c), considering homogeneous oxidation of CO in the boundary layer of the particle and reduction of CO_2 at the surface, was derived explicitly. Under conditions in practical pulverized coal flames, the energy distribution coefficient (X_c) and the effective energy distribution coefficient (X_e), based on the heat-release calculated using the traditional single film model with CO (SF-CO) as the only reaction product, were calculated and compared with the value commonly used in the SF-CO model. The results obtained show that the smaller the particle diameter, the greater the energy distribution coefficient. For the same particle diameter, the higher the particle temperature, the lower the energy distribution coefficient. Under the conditions of the calculation, the average value of the energy distribution coefficient X_c is approximately 0.7, and the average value of the effective SF-CO energy distribution coefficient is greater than 0.5, significantly larger than the value of 0.3 obtained by the traditional single film model.

08/02466 The use of petroleum coke as fuel in a 10 kW$_{th}$ chemical-looping combustor

Berguerand, N. and Lyngfelt, A. *International Journal of Greenhouse Gas Control*, 2008, 2, (2), 169–179.

Tests were made in a 10 kW$_{th}$ chemical-looping combustor with a petroleum coke as the solid fuel and the oxygen carrier ilmenite, an iron titanium oxide. The fuel reactor is fluidized by steam and the oxygen carrier reacts with the volatiles released as well as the gasification intermediates CO and H_2. A constant fuel flow corresponding to a thermal power of 5.8 kW was introduced into the fuel reactor and a total of 11 h of operation was reached. The effects of particle circulation and carbon stripper operation on solid fuel conversion, conversion of gas from the fuel reactor and CO_2 capture were investigated. The actual CO_2 capture ranged between 60% and 75% while the solid fuel conversion was in the range of 66–78%. The low values of solid fuel conversion reflect loss of char due to low efficiency of the fuel reactor cyclone. The incomplete conversion of the gas from the fuel reactor is expressed as oxygen demand. The oxygen demand corresponds to the fraction of oxygen lacking to achieve full gas conversion and was typically 25%, due to presence of CH_4, CO and H_2 from the fuel reactor. Typical ratios of CH_4, CO and H_2 over the total gaseous carbon from the fuel reactor are respectively 5, 10 and 25%. Low loss of non-combustible fines from the system indicates very low attrition of the oxygen carrier.

02 LIQUID FUELS

Sources, properties, recovery

08/02467 Autoignition measurements and a validated kinetic model for the biodiesel surrogate, methyl butanoate

Dooley, S. *et al. Combustion and Flame*, 2008, 153, (1–2), 2–32.

The autoignition of methyl butanoate has been studied at 1 and 4 atm in a shock tube over the temperature range 1250–1760 K at equivalence ratios of 1.5, 1.0, 0.5, and 0.25 at fuel concentrations of 1.0 and 1.5%. These measurements are complemented by autoignition data from a rapid compression machine over the temperature range 640–949 K at compressed gas pressures of 10, 20, and 40 atm and at varying equivalence ratios of 1.0, 0.5, and 0.33 using fuel concentrations of 1.59 and 3.13%. The autoignition of methyl butanoate is observed to follow Arrhenius-like temperature dependence over all conditions studied. These data, together with speciation data reported in the literature in a flow reactor, a jet-stirred reactor, and an opposed-flow diffusion flame, were used to produce a detailed chemical kinetic model. It was found that the model correctly simulated the effect of change in equivalence ratio, fuel fraction, and pressure for shock tube ignition delays. The agreement with rapid compression machine ignition delays is less accurate, although the qualitative agreement is reasonable. The model reproduces most speciation data with good accuracy. In addition, the important reaction pathways over each regime have been elucidated by both sensitivity and flux analyses.

08/02468 Characterization of petroleum using near-infrared spectroscopy: quantitative modeling for the true boiling point curve and specific gravity

Pasquini, C. and Bueno, A. F. *Fuel*, 2007, 86, (12–13), 1927–1934.

This work describes a new approach to predict the true boiling point (TBP) curve and to estimate the API gravity in order to characterize the petroleum processed in refineries by using the information present in its absorbance spectrum obtained in the near-infrared region (NIR). The absorbance spectra were obtained in the range from 3700 to 10,000 cm^{-1} employing a CaF_2 transmittance cell with a 0.5 mm light path. Three spectral regions were evaluated for modelling purpose: 5000–3900 cm^{-1}, 6000–3700 cm^{-1}, and 9000–700 cm^{-1}. The spectral region corresponding to the combination of C–H vibrations produces absorption spectra with very good quality while the region above 6500 cm^{-1} is dominated by scattering of the radiation. The absorbance spectra of a total of 122 samples of petroleum and petroleum blends coming from various producing regions in Brazil and abroad were obtained and pre-processed to correct for base line shift and for the integrated area. Two approaches were employed to obtain the models: one using artificial neural networks (ANN) and the other using partial least squares (PLS). The results showed that PLS gives better predictions than ANN for the API gravity and the TBP curve. The best results were obtained using the 5000–3900 cm^{-1} spectral range. In an external validation, the average RMSEP for the volume of distillate along the TBP curve employing PLS model was 1.13V% while that for API gravity was 0.24. A comparison between the results obtained by a simulator used by the refinery and the PLS model revealed a better performance for the model based on NIR spectrometry.

08/02469 Effects of fuel properties on the burning characteristics of collision-merged alkane/water droplets

Wang, C. H. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (5), 1049–1058.

The combustion characteristics of freely falling droplets, individually generated by the merging of colliding alkane and water droplets, were experimentally investigated. The outcome of the collision droplets was firstly studied and then the subsequent burning processes such as the flame appearance, ignition and burning behaviours were recorded, through either visual observation or microphotography with the aid of stroboscopic lightening. If the merged droplets were exhibited in an insertive manner, while the water droplet inserted into the alkane droplet, these yield the burning behaviours prior to the end of flame were very much similar to that of pure alkane. The burning was ended with droplet extinction for lower-C alkane, and with either droplet 'flash vaporization' or extinction for hexadecane. And if the merged droplets were in adhesive manner, for hexadecane with large water content, they either could not be ignited for the large merged droplets, or be ignited with a much prolonged ignition delay, followed by a soot-reducing flame and an ending of droplet extinction for the small merged droplets. 'Homogeneous' explosion was not observed in any of the tests, and 'heterogeneous' explosion, induced by trapped air bubbles, occasionally occurred for merged droplets with C-atom in alkane is higher than dodecane. And the sudden disappearance of droplet definitely decreased the burning time and thus enhanced the burning intensity. Besides, the fuel mass consumption rates were increased, even in the cases that having droplet extinction, because of the enlargement of the surface area due to the stuffing of water droplet.

08/02470 High-resolution monitoring of biogeochemical gradients in a tar oil-contaminated aquifer

Anneser, B. *et al. Applied Geochemistry*, 2008, 23, (6), 1715–1730.

The detailed understanding of *in situ* biodegradation of petroleum hydrocarbons in porous aquifers requires knowledge on biogeochemical gradients, the distribution of individual redox species and microorganisms. The generally limited spatial resolution of conventional monitoring wells, however, hampers appropriate characterization of small-scale gradients and thus localization of the relevant processes. Groundwater sampling across a BTEX plume in a sandy aquifer by means of a novel high-resolution multi-level well (HR-MLW) is presented here. The presence of distinct and steep biogeochemical gradients is demonstrated in the centimetre and decimetre scale, which could not be resolved with a conventional multi-level well. The thin BTEX plume with a vertical extension of only 80 cm exhibited a decline of contaminant concentrations by two orders of magnitude within a few centimetres in the upper and lower fringe zone. The small-scale distribution of sulfate, sulfide and Fe(II) in relation to the contaminants and elevated $\delta^{34}\mathrm{S}$ and $\delta^{18}\mathrm{O}$ values of groundwater sulfate strongly indicated sulfate and iron reduction to be the dominant redox processes involved in biodegradation. High microbial activities and biomass especially at the plume fringes and the slope of chemical gradients supported the concept that the latter are regulated by microbial processes and transverse dispersion, i.e. vertical mixing of electron donors and acceptors. Transverse dispersion therefore was suggested to be a driving factor controlling biodegradation in porous aquifers, but not exclusively limiting natural attenuation processes at this site. Broad overlapping zones of electron donors and electron acceptors point towards additional factors limiting anaerobic biodegradation *in situ*. The identification of small-scale gradients substantially contributed to a better understanding of biodegradation processes and hence is a prerequisite for the development of reliable predictive mathematical models and future remediation strategies.

08/02471 Mutual interactions between crude oil and CO_2 under different pressures

Nobakht, M. *et al. Fluid Phase Equilibria*, 2008, 265, (1–2), 94–103.

In this paper, the mutual interactions between a crude oil and CO_2 under different pressures and their effects on the crude oil–CO_2 interfacial tension (IFT) and the CO_2 enhanced oil recovery (EOR) are experimentally studied. Firstly, a series of crude oil–CO_2 saturation tests is conducted under different equilibrium pressures in a visual high-pressure saturation cell to determine the onset pressure of the asphaltene precipitation for the crude oil–CO_2 system. Secondly, the axisymmetric drop shape analysis (ADSA) technique for the pendant drop case is applied to measure the equilibrium IFT between the crude oil and CO_2 as a function of the equilibrium pressure at $T = 27\,^{\circ}\mathrm{C}$. The major component of the ADSA system is a see-through windowed high-pressure cell, which makes it possible to visualize the interfacial interactions between the crude oil and CO_2 under the practical reservoir conditions. It is found that the measured crude oil–CO_2 equilibrium IFT is reduced almost linearly with the equilibrium pressure, as long as it is lower than a threshold pressure. It is observed that if the equilibrium pressure is high enough, the light components in the original crude oil are quickly extracted from the oil drop to CO_2 phase at the beginning. This physical phenomenon is referred to as the initial strong light-components extraction. The onset pressure of the initial strong light-components extraction is found to be higher than that of the asphaltene precipitation for the crude oil–CO_2 system determined in the saturation tests. Thirdly, a series of CO_2 coreflood tests is performed to study the effect of the mutual interactions between the crude oil and CO_2 under different CO_2 injection pressures on the CO_2 EOR. The detailed CO_2 coreflood test results show that the CO_2 EOR is increased sharply with the CO_2 injection pressure only if it is in an intermediate range.

08/02472 Observations and morphological analysis of supermolecular structure of natural bitumens by atomic force microscopy

Golubev, Y. A. *et al. Fuel*, 2008, 87, (1), 32–38.

The supermolecular structures of natural bitumens of the thermal consequent row *asphaltites* → *lower kerites* (*albertites*) → *higher kerites* (*impsonites*) → *anthraxolites* come from the Timan–Pechora petroleum province and Karelian shungite rocks in Russia were studied in details. The experimental technique used was atomic force microscopy (AFM), following fracture preparation. The element distribution of the sample surfaces was analysed by an X-ray microanalyser 'Link ISIS', combined with a scanning electron microscope (SEM). In this work, the authors characterized the supermolecular evolution of natural solid bitumens in the carbonization sequence by quantitative parameters. It is shown that supermolecular structure can be important in defining to which classification group solid bitumens belong.

08/02473 Reliability of pipelines with corrosion defects

Teixeira, A. P. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 228–237.

This paper aims at assessing the reliability of pipelines with corrosion defects subjected to internal pressure using the first-order reliability method (FORM). The limit-state function is defined based on the results of a series of small-scale experiments and three-dimensional non-linear finite element analysis of the burst pressure of intact and corroded pipelines. A sensitivity analysis is performed for different levels of corrosion damage to identify the influence of the various parameters in the probability of burst collapse of corroded and intact pipes. The Monte Carlo simulation method is used to assess the uncertainty of the estimates of the burst pressure of corroded pipelines. The results of the reliability, sensitivity and uncertainty analysis are compared with results obtained from codes currently used in practice.

08/02474 Spray inner structure of evaporating multi-component fuel

Myong, K.-J. *et al. Fuel*, 2008, 87, (2), 202–210.

This study was conducted to assess the effect of the composition of mixed fuels on the spray inner structure in an evaporating transient spray under various ambient conditions. The spray structure and spatial distribution of the liquid phase of the multi-component fuels (three-component mixed fuels) were investigated using thin laser sheet illumination with a pulsed Nd-YAG laser as the light source. The experiments were conducted in a constant-volume vessel with optical access. Fuel was injected into the vessel with an electronically controlled common rail injector. In low-volatility multi-component fuel, droplet clusters occur at almost regular intervals resulting from fuel properties such as high liquid density and viscosity of a fuel with a high boiling point.

08/02475 Storage stability of poultry fat and diesel fuel mixtures: specific gravity and viscosity

Geller, D. P. *et al. Fuel*, 2008, 87, (1), 92–102.

Poultry fat (biofuel) and its 20%, 40%, 60% and 80% mixtures with #2 pump diesel fuel were stored for 1 year at bench scale (1 L) under controlled laboratory conditions at 4, 38, 54.4 °C and at ambient room temperature. Poultry fat (100%) was studied under these same conditions with and without an antioxidant additive. Poultry fat mixtures (20% and 80%) were also stored at pilot scale (250 gallons) under outdoor, ambient conditions. Physical properties and phenomenon relevant to the use of these mixtures as biofuels for industrial boilers were studied and tracked. These properties include specific gravity, dynamic viscosity, sedimentation accumulation and separation (layering). Corrosive effects of these fuels on various metals were also examined. Viscosity and specific gravity of these biofuels changed very little over the course of the 1 year storage period. Sediment accumulation was present in all treatments, with increasing sedimentation correlating with increasing biofuel concentrations. The addition of antioxidant to 100% biofuel minimized changes in physical properties and sedimentation over the course of this study. Layering occurred in all mixtures of poultry fat and diesel fuel. Results also include the approximate amount of energy required to insure proper mixing of each treatment. After mixing, homogenization was maintained for considerable time periods. This suggests that mixing should only be performed immediately before the fuels are utilized. Corrosive properties of these biofuels were generally as expected; brass and copper were susceptible to attack by these fuels where as 316 stainless steel and carbon steel were not.

08/02476 Structure and thermodynamic consistency of heavy oils: a study on the basis of acoustic measurements

Plantier, F. *et al. Fuel*, 2008, 87, (2), 196–201.

The present work proposes a methodology combining acoustic, volumetric and calorimetric measurements in order to characterize thermophysical behaviours of heavy oils under conditions similar to those encountered during their production and/or transportation. Ultrasonic velocity measurements were performed in two heavy oils from 283.15 to 373.15 K at pressures up to 20 MPa. Further volumetric measurements, i.e. density, were carried out in the same ranges while heat capacity was determined at the only atmospheric pressure from 300.15 to 373.15 K. Comparisons between direct ultrasonic velocity measurements and calculated speed of sound from its thermodynamic definition which involves both volumetric and calorimetric measurements exhibit a strong divergence below a temperature of 320 K. This difference between the two sets of data means that thermodynamic consistency is not complete, which can mean a singular thermophysical behaviour of such fluids.

08/02477 Thermal stability of biodiesel in supercritical methanol

Imahara, H. *et al. Fuel*, 2008, 87, (1), 1–6.

Non-catalytic biodiesel production technologies from oils/fats in plants and animals have been developed in the laboratory employing supercritical methanol. Due to conditions in high temperature and high pressure of the supercritical fluid, thermal stability of fatty acid methyl esters and actual biodiesel prepared from various plant oils was studied in supercritical methanol over a range of its condition between 270 °C/17 MPa and 380 °C/56 MPa. In addition, the effect of thermal degradation on cold flow properties was studied. As a result, it was found that all fatty acid methyl esters including poly-unsaturated ones were stable at 270 °C/17 MPa, but at 350 °C/43 MPa, they were partly decomposed to reduce the yield with isomerization from *cis*-type to *trans*-type. These behaviours were also observed for actual biodiesel prepared from linseed oil, safflower oil, which are high in poly-unsaturated fatty acids. Cold flow properties of actual biodiesel, however, remained almost unchanged after supercritical methanol exposure at 270 °C/17 MPa and 350 °C/43 MPa. For the latter condition, however, poly-unsaturated fatty acids were sacrificed to be decomposed and reduced in yield. From these results, it was clarified that reaction temperature in supercritical methanol process should be lower than 300 °C, preferably 270 °C with a supercritical pressure higher than 8.09 MPa, in terms of thermal stabilization for high-quality biodiesel production.

Transport, refining, quality, storage

08/02478 Cobalt supported on carbon nanotubes – a promising novel Fischer–Tropsch synthesis catalyst

Tavasoli, A. *et al. Fuel Processing Technology*, 2008, 89, (5), 491–498.

An extensive study of Fischer–Tropsch synthesis (FTS) on carbon nanotubes (CNT) supported and γ–alumina-supported cobalt catalysts with different amounts of cobalt are reported. Up to 40 wt.% of cobalt is added to the supports by the impregnation method. The effect of the support on the reducibility of the cobalt oxide species, dispersion of the cobalt, average cobalt clusters size, water–gas shift activity and activity and selectivity of FTS is investigated. Using carbon nanotubes as cobalt catalyst support was found to cause the reduction temperature of cobalt oxide species to shift to lower temperatures. The strong metal-support interactions are reduced to a large extent and the reducibility of the catalysts improved significantly. CNT aided in well dispersion of metal clusters and average cobalt clusters size decreased. Results are presented showing that the hydrocarbon yield obtained by inventive CNT supported cobalt catalyst is surprisingly much larger than that obtained from cobalt on alumina supports. The maximum concentration of active surface Co° sites and FTS activity for alumina and CNT supported catalysts are achieved at 34 wt.% and 40 wt.% cobalt loading respectively. CNT caused a slight decrease in the FTS product distribution to lower molecular weight hydrocarbons.

08/02479 Determination of horizontal permeability from the elliptical flow of horizontal wells using conventional analysis

Escobar, F. H. and Montealegre-M, M. *Journal of Petroleum Science and Engineering*, 2008, 61, (1), 15–20.

Besides the regular four flow regimes normally seen during a pressure test of horizontal wells, it is possible, under special circumstances, to observe such additional flow regimes as spherical, hemi-radial, linear (reservoir channel) and elliptical. The last flow regime is characterized by a slope of 0.36 of the pressure derivative curve and occurs between the early linear flow and the pseudo-radial flow periods. This may have been overlooked in horizontal well test analysis, because it is often masked by the other flow regimes, unless the conditions are just right. The elliptical flow regime has been previously mentioned by very few researchers. However, conventional analysis for the characterization of this has not yet been reported in the literature. This flow regime is very useful to estimate the horizontal permeability, especially, when the pseudo-radial flow is very short or unclear, or simply, when it is desired to verify that estimation. In this paper, equations for the estimation of the horizontal permeability and elliptical skin factor are developed for both gas and oil horizontal wells, so that the mentioned parameters can be estimated, respectively, from the slope and intercept of linear plot of pressure versus time to the power 0.36. The equations were successfully tested with two field examples previously worked in the literature.

08/02480 Development of an artificial neural network correlation for prediction of hold-up of slurry transport in pipelines

Lahiri, S. K. and Ghanta, K. C. *Chemical Engineering Science*, 2008, 63, (6), 1497–1509.

In the literature, very few correlations have been proposed for hold-up prediction in slurry pipelines. However, these correlations fail to predict hold-up over a wide range of conditions. Based on a databank of around 220 measurements collected from the open literature, a correlation for hold-up was derived using artificial neural network (ANN) modelling. The hold-up for slurry was found to be a function of nine parameters such as solids concentration, particle diameter, slurry velocity, pressure drop and solid and liquid properties. Statistical analysis showed that the proposed correlation has an average absolute relative error of 2.5% and a standard deviation of 3.0%. A comparison with selected correlations in the literature showed that the developed ANN correlation noticeably improved prediction of hold-up over a wide range of operating conditions, physical properties and pipe diameters. This correlation also predicts properly the trend of the effect of the operating and design parameters on hold-up.

08/02481 Electro-oxidation of methanol, 1-propanol and 2-propanol on Pt and Pd in alkaline medium

Liu, J. *et al. Journal of Power Sources*, 2008, 177, (1), 67–70.

Pd is investigated as electrocatalyst for 1-propanol and 2-propanol oxidation and compared with the conventional catalyst of Pt in alkaline medium. The results show that Pd is a good electrocatalyst for 1-propanol and 2-propanol oxidation. The oxidation reaction of 1-propanol and 2-propanol shows a very low activity on Pt electrode, however the oxidation reaction of 1-propanol and 2-propanol shows a high activity on Pd electrode in alkaline medium. The current densities of 1-propanol and 2-propanol oxidation on Pd electrode are much higher at corresponding potentials than that of methanol oxidation and the onset potentials of 1-propanol and 2-propanol oxidation on Pd electrode are more negative compared with that of methanol oxidation. The 1-propanol and 2-propanol oxidation on Pd electrode shows a stable performance. The results show that Pd can take the place of Pt for 1-propanol and 2-propanol oxidation in alkaline medium. The present study shows a promising choice of Pd as effective electrocatalyst for 1-propanol and 2-propanol electro-oxidation in alkaline medium.

08/02482 Heavy crude oil hydroprocessing: a zeolite-based CoMo catalyst and its spent catalyst characterization

Rana, M. S. *et al. Catalysis Today*, 2008, 130, (2–4), 411–420.

This study presents an effect of zeolite with alumina as a support for heavy oil hydroprocessing. The high surface area, moderately acidic meso- and macro-porous support was prepared with the mixing of alumina and ultra-stable Y zeolite. The micro-structure and the composition of the zeolite crystals formed in the bulk of the alumina were examined by scanning electron microscopy with energy dispersive X-ray analysis, and there were two main crystal phases homogeneously distributed in it. A CoMo sulfide supported catalyst is evaluated for hydroconversion of Maya heavy crude oil at moderate pressure conditions. The combination of ultra-stable zeolite and alumina is able to produce bi-modal type of pores in the catalyst which may contribute to a better combination of hydrodesulfurization (HDS), hydrodemetallization (HDM) and the selective cracking of asphaltene over the acidic catalysts. The characterization of spent catalysts can help as an assistance for the selection of optimum catalyst properties along with the reactor bed length and type of catalyst pore in each bed. The strapping reaction condition indicated that the acidic catalyst for heavy oil can be used more effectively at lower temperature. An increase in temperature showed that the HDM and hydrogenation of asphaltenes (HDAs) conversions are more affected than HDS and HDN. These results indicate occurrence of a thermal cracking of complex molecules like asphaltene and metal porphyrins, which is confirmed by the gaseous selectivity of the hydrocarbons.

08/02483 Hydroprocessing peculiarities of Fischer–Tropsch syncrude

de Klerk, A. *Catalysis Today*, 2008, 130, (2–4), 439–445.

When catalysts developed for crude oil hydroprocessing are used for syncrude, there are syncrude-specific peculiarities to consider. These relate to differences in the nature and abundance of heteroatoms, olefins, metal species, waxes and aqueous products. Some important aspects are (a) heat release during naphtha and distillate hydroprocessing is very high, but wax hydrocracking is almost isothermal; (b) syncrude is sulfur-free and the use of sulphided base-metal hydroprocessing catalysts require the addition of sulfur-containing compounds to the syncrude; (c) oxygenates strongly adsorb on some catalytic surfaces to affect catalytic behaviour; (d) carbonyl–carboxylic acid interconversion and water produced by hydrodeoxygenation (HDO) may result in catalyst degradation by acid and hydrothermal attack; (e) carboxylic acids in syncrude result in equipment corrosion and catalyst leaching; (f) metal carboxylates are the main metal-containing species in syncrude and are not removed by hydrodemetallation (HDM) catalysis, but by thermal decomposition.

08/02484 Imidazolium-based alkylphosphate ionic liquids – a potential solvent for extractive desulfurization of fuel

Jiang, X. *et al. Fuel*, 2008, 87, (1), 79–84.

N-ethyl-imidazolium-based alkylphosphate ionic liquid (IL), viz. *N*-ethyl-*N*-methyl-imidazolium dimethylphosphate ([EMIM][DMP]), *N*-ethyl-*N*-ethyl-imidazolium diethylphosphate ([EEIM][DEP]) and *N*-butyl-*N*-ethyl-imidazolium dibutylphosphate ([BEIM][DBP]) were demonstrated to be effective for the removal of aromatic sulfur compounds (S-compound) 3-methylthiophene (3-MT), benzothiophene (BT) and dibenzothiophene (DBT) from fuel oils in terms of sulfur partition coefficients (*KN*) at 298.15 K. It was shown that the extractive ability of the alkylphosphate ILs was dominated by the structure of the cation and followed the order [BEIM][DBP] > [EEIM][DEP] > [EMIM][DMP] for each S-compound studied with their *KN*-value being 1.72, 1.61 and 1.17, respectively for DBT. For a specified IL the sulfur selectivity followed the order DBT > BT > 3-MT with their *KN*-value being 1.61, 1.39 and 0.78, respectively for [EEIM][DEP]. The alkylphosphate ILs are insoluble in fuel while the fuel solubility in ILs varies from 20.6 mg(fuel)/g(IL) for [EMIM][DMP] to 266.9 mg(fuel)/g(IL) for [BEIM][DBP]. The results suggest that [EEIM][DEP] might be used as a promising solvent for the extractive desulfurization of fuel, considering its higher sulfur extractive ability, lower solubility for fuel and thus negligible influence on the constituent of fuel, and the ease of regeneration for the spent IL via water dilution process.

08/02485 Low-emission diesel production by upgrading LCO plus SR diesel fractions

Tailleur, R. G. *Catalysis Today*, 2008, 130, (2–4), 492–500.

The performance of commercial hydrotreating units that use 15% LCO/85% SRGO as feed stock and a MoNi/Al$_2$O$_3$-type catalyst to produce 30-ppm sulfur diesel was followed along the cycle length. The products generated at the 1st, 8th and 14th months on stream were deeply characterized to enable understanding of the changes in quality along the cycle length. Three catalyst samples at the end of run were obtained from the reactor and characterized. Furthermore, a WNiPd/TiO$_2$Al$_2$O$_3$ catalyst, deactivated in the pilot plant during 3 months in operation with 100% LCO as feedstock, was then used to process the same feedstock as in the commercial unit. A diesel engine test was done with the three products obtained along the cycle length as well as with others obtained in the pilot plant to check the effect of deactivation on emissions. The results confirmed metal and acid site deactivation, decrease of cetane number and increase in emissions along the cycle length. The test with a synthetic feed demonstrates that the metal sites on the catalysts deactivated more slowly than the isomerization and cracking ones.

08/02486 Modification of a thermodynamic model and an equation of state for accurate calculation of asphaltene precipitation phase behavior

Nikookar, M. *et al. Fuel*, 2008, 87, (1), 85–91.

In this study, the DPTG (Dashtizadeh–Pazuki–Taghikhani–Ghotbi) equation of state has been modified for calculation of phase behaviour of fluids and solubility parameter. The accuracy of the modified EOS has been proved by estimation of the properties of some hydrocarbons such as densities of methane and condensate gases, vaporization enthalpy, sublimation pressure, compressibility factor and comparison of the obtained results with the results of the present equations of state such as NJ (Nasrifar–Jalali), ZMJL (Zhi–Meiren–Jun–Lee) and PR (Peng–Robinson). Then, the Flory–Huggins model has been modified and asphaltene precipitation phase behaviour at different ratios of solvents in the crude oil has been predicted by the modified EOS and the developed Flory–Huggins model. Comparison of the obtained results with the experimental data of asphaltene precipitation and the calculated ones by the main Flory–Huggins model shows the accuracy of the developed model.

08/02487 Oil prices: the role of refinery utilization, futures markets and non-linearities

Kaufmann, R. K. *et al. Energy Economics*, 2008, 30, (5), 2609–2622.

In this paper, the hypothesis that real oil prices are determined in part by refinery capacity is tested, non-linearities in supply conditions, and/or expectations and that observed changes in these variables can account for the rise in prices between 2004 and 2006. Results indicate that the refining sector plays an important role in the recent price increase, but not in the way described by many analysts. The relationship is negative such that higher refinery utilization rates reduce crude oil prices. This effect is associated with shifts in the production of heavy and light grades of crude oil and price spreads between them. Non-linear relationships between OPEC capacity and oil prices as well as conditions on the futures markets also account for changes in real oil prices. Together, these factors allow the model to generate a one-step ahead out-of-sample forecast that performs as well as forecasts implied by far-month contracts on the New York Mercantile Exchange and is able to account for much of the $27 rise in crude oil prices between 2004 and 2006.

08/02488 On-column precipitation and re-dissolution of asphaltenes in petroleum residua

Schabron, J. F. and Rovani , J. F. *Fuel*, 2008, 87, (2), 165–176.

A new automated separation technique was developed for measuring the distribution profiles of the most polar, or asphaltenic components of an oil, using a continuous flow system to precipitate and re-dissolve asphaltenes. Methods of analysis based on this new technique were explored. One method based on the new technique involves precipitation of a portion of residua sample in heptane on a polytetrafluoroethylene-packed (PTFE) column. The precipitated material is re-dissolved in three steps using solvents of increasing polarity: cyclohexane, toluene, and methylene chloride. The amount of asphaltenes that dissolve in cyclohexane is a useful diagnostic of the thermal history of an oil, and its proximity to coke formation. For example, about 40% (w/w) of the heptane asphaltenes from unpyrolysed residua dissolves in cyclohexane. As pyrolysis progresses, this number decrease to below 15% as coke and toluene-insoluble pre-coke materials appear. Currently, the procedure for the isolation of heptane asphaltenes and the determination of the amount of asphaltenes soluble in cyclohexane spans three days. The automated procedure takes one hour. Another method uses a single solvent, methylene chloride, to re-dissolve the material that precipitates in heptane on the PTFE-packed column. The area of this second peak can be used to calculate a value which correlates with gravimetric asphaltene content. Currently the gravimetric procedure to determine asphaltenes takes about 24 h. The automated procedure takes 30 min. Results for four series of original and pyrolysed residua were compared with data from the gravimetric methods. Methods based on the new on-column precipitation and re-dissolution technique provide significantly more detail about the polar constituents oils than the gravimetric determination of asphaltenes.

08/02489 Overseas oil-development policy of resource-poor countries: a case study from Japan

Koike, M. *et al. Energy Policy*, 2008, 36, (5), 1764–1775.

Japan, currently the world's third largest oil consumer, depends on imports for almost all of its oil needs. Owing to this high level of dependence, Japanese citizens as well as the economy have historically been vulnerable. In the past, certain incidents caused by the interruption of oil imports have resulted in fatal damages to the country. In order to reduce these risks, the Japanese government has supported overseas exploration and development activities of the domestic upstream oil industry, which has not proven as successful as expected. This paper presents the experiences, policies, and the structure of Japan's attempts to increase the share of domestic oil needs met by development activities. While conducting this study, both internal and external constraints were encountered. In addition to the lack of domestic oil reserves, factors including the institutional design of cooperation between government and private industries, the early history of the upstream industry, the target area of overseas development, and the changing environment have created impediments toward achieving the targets. In 2006, Japan again set a new target for doubling the ratio of self-developed oil in its total imports by 2030, and will face challenges in clearing the above-mentioned hurdles.

Economics, business, marketing, policy

08/02490 A meta-analysis of the price elasticity of gasoline demand. A SUR approach

Brons, M. *et al. Energy Economics*, 2008, 30, (5), 2105–2122.

Automobile gasoline demand can be expressed as a multiplicative function of fuel efficiency, mileage per car and car ownership. This implies a linear relationship between the price elasticity of total fuel demand and the price elasticities of fuel efficiency, mileage per car and car ownership. In this meta-analytical study the aim is to to investigate and explain the variation in empirical estimates of the price elasticity of gasoline demand. A methodological novelty is that the authors use the linear relationship between the elasticities to develop a meta-analytical estimation approach based on a seemingly unrelated regression model with cross equation restrictions. This approach enables us to combine observations of different elasticities and thus increase the sample size. Furthermore, it allows for a more detailed interpretation of the meta-regression results. The empirical results of the study demonstrate that the SUR approach leads to more precise results (i.e. lower standard errors) than a standard meta-analytical approach. It is found that, with mean short run and long run price elasticities of –0.34 and –0.84, respectively, the demand for gasoline is not very price sensitive. Both in the short and the long run, the impact of a change in the gasoline price on demand is mainly driven by responses in fuel efficiency and mileage per car and to a slightly lesser degree by changes in car ownership. Furthermore, the authors find that study characteristics relating to the geographic area studied, the year of the study, the type of data used, the time horizon and the functional specification of the demand equation have a significant impact on the estimated value of the price elasticity of gasoline demand.

08/02491 A model of the operation and development of a national oil company

Hartley, P. *et al. Energy Economics*, 2008, 30, (5), 2459–2485.

In this paper, the authors present a model of the exploration and development activities of a national oil company (NOC), which uses similar technology to a private firm to extract a depletable resource. However, unlike the private firm, the NOC may have a wider range of objectives than maximizing the present value of profits. Specifically, it is assumed that an objective function that balances firm profitability against a political desire to favour domestic consumer surplus and domestic employment. It is find that the non-commercial objectives faced by a NOC tend to reinforce each other in their effects on profitability, the timing of cash flows and employment.

08/02492 An empirical analysis of the dynamic programming model of stockpile acquisition strategies for China's strategic petroleum reserve

Wu, G. *et al. Energy Policy*, 2008, 36, (4), 1470–1478.

The world's future oil price is affected by many factors. The challenge, therefore, is how to select optimal stockpile acquisition strategies to minimize the cost of maintaining a reserve. This paper provides a new method for analysing this problem using an uncertain dynamic programming model to analyse stockpile acquisition strategies for strategic petroleum reserve. Using this model, the authors quantify the impact of uncertain world oil price on optimal stockpile acquisition strategies of China's strategic petroleum reserve for the period 2007–2010 and 2011–2020. The results show that the future stockpile acquisition is related to oil prices and their probability and, if not considering the occurrence of oil supply shortage, China should at least purchase 25 million barrels when world oil price is at an optimal level. The optimal price of stockpile acquisition of every year has a stronger relationship with the probability of high price; and the optimal expected price and size of stockpile acquisition is different in each year.

08/02493 Electronic trading system and returns volatility in the oil futures market

Liao, H.-C. *et al. Energy Economics*, 2008, 30, (5), 2636–2644.

This paper uses daily Brent crude prices to investigate the employment of electronic trading on the returns conditional volatility in the oil futures market. After a suitable GARCH model is established, the conditional volatility series are found. The Bai and Perron model is then used to find two significant structural breaks for these conditional volatility series around two implementation dates of electronic trading. This result indicates that the change in the trading system has significant impacts on the returns volatility since the estimated second break date is very close to the all-electronic trade implementation date. Moreover, the conditional volatility in the all-electronic trading period is found to be more dominated by the temporal persistence rather than the volatility clustering effect. All these evidence can shed some light for explaining the high relationship between more volatile world oil price and the more popular electronic trade.

08/02494 Global oil peaking: responding to the case for 'abundant supplies of oil'

Meng, Q. Y. and Bentley, R. W. *Energy*, 2008, 33, (8), 1179–1184.

This paper examines aspects of the case against global oil peaking, and in particular sets out to answer a viewpoint that the world can have abundant supplies of oil 'for years to come'. Arguments supporting the latter view include: past forecasts of oil shortage have proved incorrect, so current predictions should also be discounted; many modellers depend on Hubbert's analysis but this contained fundamental flaws; new oil supply will result from reserves growth and from the wider deployment of advanced extraction technology; and that the world contains large resources of unconventional oil that can come on-stream if the production of conventional oil declines. These arguments are examined in turn and shown to be incorrect, or to need setting into a broader context. The paper concludes therefore that such arguments cannot be used to rule out calculations that the resource-limited peak in the world's production of conventional oil will occur in the near term. Moreover, peaking of conventional oil is likely to impact the world's total availability of oil where the latter includes non-conventional oil and oil substitutes.

08/02495 Liquefied petroleum gas containing sulfur as the carbon source for carbon nanotube forests

Huang, J. *et al. Carbon*, 2008, 46, (2), 291–296.

Carbon nanotube (CNT) forests were obtained from liquefied petroleum gas (LPG) as the carbon source in the floating catalyst process. The CNTs obtained in the forest had a thinner diameter and lower growth rate than those obtained with other carbon sources, which was attributed to the existence of sulfur in the LPG. The use of unpurified LPG provides a controllable way to synthesize a CNT forest at low cost.

08/02496 Oil price dynamics (2002–2006)

Askari, H. and Krichene, N. *Energy Economics*, 2008, 30, (5), 2134–2153.

Oil price dynamics during 2002–2006 have been characterized by high volatility, high intensity jumps, and strong upward drift, and were concomitant with underlying fundamentals of oil markets and world economy; namely, pressure on oil prices resulting from rigid crude oil supply and expanding world demand for crude oil. A change in the oil price process parameters would require a change in underlying fundamentals. Market expectations, extracted from call and put option prices, anticipated no change in underlying fundamentals in the short term. Markets expected oil prices to remain volatile and jumpy, and with higher probabilities, to rise, rather than fall, above the expected mean.

08/02497 Perspectives on fuel ethanol consumption and trade

Walter, A. *et al. Biomass and Bioenergy*, 2008, 32, (8), 730–748.

Since the year 2000 or so there has been a rapid growth on fuel ethanol production and consumption, particularly in the USA and Brazil. Ethanol trade represented about 10% of world consumption in 2005, Brazil being the main exporter. The most important consumer markets – the USA and the European Union (EU) – have trade regimes that constrained the comparative advantages of the most efficient producers, such as Brazil. This paper evaluates the fuel ethanol market up to 2030 together with the potential for international biotrade. Based on forecasts of gasoline consumption and on targets and mandates of fuel ethanol use, it is estimated that demand could reach 272 Gl in 2030, displacing 10% of the estimated demand of gasoline (scenario 1), or even 566 Gl in the same year, displacing about 20% of the gasoline demand (scenario 2). The analysis considers fuel ethanol consumption and production in the USA, EU-25, Japan, China, Brazil and the rest of the world (ROW-BR). Without significant production of ethanol from cellulosic materials in this period, displacing 10% of the gasoline demand in 2030, at reasonable cost, can only be accomplished by fostering fuel ethanol production in developing countries and enhancing ethanol trade. If the US and EU-25 reach their full production potential (based on conventional routes), the minimum amount that could be traded in 2030 would be about 34 Gl. Displacing 20% of the gasoline demand by 2030 will require the combined development of second-generation technologies and large-scale international trade in ethanol fuel. Without second-generation technologies, Scenario 2 could become a reality only with large-scale production of ethanol from sugarcane in developing countries, e.g. Brazil and ROW-BR could be able to export at least 14.5 Gl in 2010, 73.9 Gl in 2020 and 71.8 Gl in 2030.

08/02498 Short-term predictability of crude oil markets: a detrended fluctuation analysis approach

Alvarez-Ramirez, J. *et al. Energy Economics*, 2008, 30, (5), 2645–2656.

This paper analyses the auto-correlations of international crude oil prices on the basis of the estimation of the Hurst exponent dynamics for returns over the period from 1987 to 2007. In doing so, a model-free statistical approach – detrended fluctuation analysis – that reduces the effects of non-stationary market trends and focuses on the intrinsic auto-correlation structure of market fluctuations over different time horizons, is used. Tests for time variations of the Hurst exponent indicate that over long horizons the crude oil market is consistent with the efficient market hypothesis. However, meaningful auto-correlations cannot be excluded for time horizons smaller than one month where the Hurst exponent manifests cyclic, non-periodic dynamics. This means that the market exhibits a time-varying short-term inefficient behaviour that becomes efficient in the long term. The proposed methodology and its findings are put in perspective with previous studies and results.

08/02499 The effect of flex fuel vehicles in the Brazilian light road transportation

Kamimura, A. and Sauer, I. L. *Energy Policy*, 2008, 36, (4), 1574–1576.

The retaking of the ethanol program in the year 2003 as a fuel for light road transportation in Brazil through the introduction of flex fuel vehicles fleet was a good strategy to overcome the difficulties of the ethanol production sector and did work to increase its market share relative to gasoline. This process, however, may cause a future disequilibrium on the food production and on the refining oil derivates structure. In order to analyse the substitution process resultant of the competition between two opponents fighting for the same market, in this case the gasoline/ethanol substitution process, a method derived from the biomathematics based on the non-linear differential equations (NLDE) system is utilized. A brief description of the method is presented. Numerical adherence of the method to explain several substitution phenomena that occurred in the past is presented in the previous author's paper, in which the urban gas pipeline system substitution of bottled LPG in the dwelling sector and the substitution of the urban diesel transportation fleet by compressed natural gas (CNG) buses is presented. The proposed method is particularly suitable for prospective analysis and scenarios assessment.

08/02500 The relationship between crude oil spot and futures prices: cointegration, linear and nonlinear causality

Bekiros, S. D. and Diks, C. G. H. *Energy Economics*, 2008, 30, (5), 2673–2685.

The present study investigates the linear and non-linear causal linkages between daily spot and futures prices for maturities of one, two, three and four months of West Texas Intermediate (WTI) crude oil. The data cover two periods October 1991–October 1999 and November 1999–October 2007, with the latter being significantly more turbulent. Apart from the conventional linear Granger test a new non-parametric test is applied for non-linear causality by Diks and Panchenko after controlling for cointegration. In addition to the traditional pairwise analysis, the authors test for causality while correcting for the effects of the other variables. To check if any of the observed causality is strictly non-linear in nature, the non-linear causal relationships of VECM filtered residuals are also examined. Finally, the authors investigate the hypothesis of non-linear non-causality after controlling for conditional heteroskedasticity in the data using a GARCH-BEKK model. Whilst the linear causal relationships disappear after VECM cointegration filtering, non-linear causal linkages in some cases persist even after GARCH filtering in both periods. This indicates that spot and futures returns may exhibit asymmetric GARCH effects and/or statistically significant higher order conditional moments. Moreover, the results imply that if non-linear effects are accounted for, neither market leads or lags the other consistently, videlicet the pattern of leads and lags changes over time.

08/02501 The sustainability of Brazilian ethanol – an assessment of the possibilities of certified production

Smeets, E. *et al. Biomass and Bioenergy*, 2008, 32, (8), 781–813.

In this article the environmental and socio-economical impacts of the production of ethanol from sugarcane in the state of São Paulo (Brazil) are evaluated. Subsequently, an attempt is made to determine to what extent these impacts are a bottleneck for a sustainable and certified ethanol production. Seventeen environmental and socio-economic areas of concern are analysed. Four parameters are used to evaluate if an area of concern is a bottleneck: (1) the importance of the area of concern, based on the severity of the impact and the frequency of which an aspect is mentioned in the literature as an area of concern, (2) the availability of indicators and criteria, (3) the necessity of improvement strategies to reach compliance with Brazilian and/or (inter-) national legislation, standards, guidelines and sustainability criteria, and (4) the impact of these improvement strategies on the costs and potential of ethanol production. Fourteen areas of concern are classified as a minor or medium bottleneck. For seven areas of concern the additional costs to avoid or reduce undesirable effects have been calculated at +10% for each area of concern. Due to higher yields and overlapping costs the total additional production costs of compliance with various environmental and socio-economic criteria are about +36%. This study also shows that the energy input to output ratio can be increased and the greenhouse gas emissions reduced by increasing the ethanol production per tonne cane and by increasing the use of sugarcane waste for electricity production. A major bottleneck for a sustainable and certified production is the increase in cane production and the possible impacts on biodiversity and the competition with food production. Genetically modified cane is presently being developed, but is at this moment not (yet) applied. Both a ban on and the allowance of the use of genetically modified cane could become a major bottleneck considering the potentially large benefits and disadvantages, that are both highly uncertain at this moment. The approach demonstrated in this report provides a useful framework for the development of a practically applicable certification system, but further monitoring and research is required to reduce gaps in knowledge in combination with stakeholder consultation (particularly with respect to the three bottlenecks identified in this article).

08/02502 Understanding the oil price-exchange rate nexus for the Fiji islands

Narayan, P. K. *et al. Energy Economics*, 2008, 30, (5), 2686–2696.

In this paper, the relationship between oil price and the Fiji–US exchange rate is examined using daily data for the period 2000–2006. The authors use the generalized autoregressive conditional heteroskedasticity (GARCH) and exponential GARCH (EGARCH) models to estimate the impact of oil price on the nominal exchange rate. It is found that a rise in oil prices leads to an appreciation of the Fijian dollar vis-à-vis the US dollar.

08/02503 Why do oil prices jump (or fall)?

Wirl, W. *Energy Policy*, 2008, 36, (3), 1029–1043.

This paper discusses theories that can explain the zig-zags of oil prices in general and in particular the recent jump. More precisely, the following explanations are discussed: *Homo economicus* (pure profit maximization if demand is dynamic and convex), price reaction function (price increases and respectively declines depend on capacity utilization), cartelization contingent on output or revenues of which the latter can lead to backward bending supply segments and multiple equilibria, statistical descriptions (mean reversion), *Homo politicus*, i.e. arguments for price hikes that are rational (public choice) despite the (long-run) economic loss. Finally two approaches are presented that emphasize demand uncertainty: one extending the above-mentioned dynamic demand framework and the other considers a dynamic game of non-competitive suppliers with lumpy investments. Summing up, a demand shock seems to be the most suitable explanation of today's high prices [indeed a shock given that International Energy Agency (IEA) and Department of Energy (DoE) were promising just a couple of years ago that we are going to have lots of oil at low prices], while others and in particular politics have surprisingly little or no explanatory power.

Derived liquid fuels

08/02504 A two-stage catalyst bed concept for conversion of carbon dioxide into methanol

Rahimpour, M. R. *Fuel Processing Technology*, 2008, 89, (5), 556–566.
Conversion of CO_2 into methanol by catalytic hydrogenation has been recognized as one of the most promising processes for stabilizing the atmospheric CO_2 level, and furthermore the methanol produced could be used as fuel or basic chemical for satisfying the large demand worldwide. The present work investigates a two-stage catalyst bed concept for conversion of CO_2 to methanol. A system with two catalyst beds instead of one single catalyst bed is developed for conversion of CO_2 to methanol. In the first catalyst bed, the synthesis gas is partly converted to methanol in a conventional water-cooled reactor. This bed operates at higher than normal operating temperature and at high yield. In the second bed, the reaction heat is used to pre-heat the feed gas to the first bed. The continuously reduced temperature in this bed provides increasing thermodynamic equilibrium potential. In this bed, the reaction rate is much lower and, consequently, so is the amount of the reaction heat. This feature results in milder temperature profiles in the second bed because less heat is liberated compared to the first bed. In this way the catalysts are exposed to less extreme temperatures and, catalyst deactivation via sintering is circumvented. In this work, a one-dimensional dynamic plug flow dynamic is used to analyse and compare the performance of two-stage bed and conventional single bed reactors. The results of this work show that the two-stage catalyst bed system can be operated with higher conversion and longer catalyst life time.

08/02505 Development of an anthraquinone process for the production of hydrogen peroxide in a trickle bed reactor – from bench scale to industrial scale

Chen, Q. *Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 780–786.
This paper discusses the development of an anthraquinone auto-oxidation process for the production of hydrogen peroxide with the focus on its key step – liquid-phase hydrogenation of active anthraquinones over Pd/Al_2O_3 catalyst. The main issues considered in the process development were the selection of a trickle bed as the hydrogenation reactor, the degradation of active anthraquinones and regeneration of their degradation by-products, the development of a new spherical Pd/Al_2O_3 hydrogenation catalyst, its deactivation and regeneration, and the examination of its activity, selectivity, life, etc. The establishment of start-up and normal operational procedures ensured minimum degradation of active anthraquinones and maximum stable operation. The experimental results from bench and pilot tests paved the way toward industrial production of hydrogen peroxide.

08/02506 Hydro-treatment of a direct coal liquefaction residue and its components

Li, J. *et al. Catalysis Today*, 2008, 130, (2–4), 389–394.
Direct coal liquefaction residue (DCLR) contains a significant fraction of heavy liquids. Better use of DCLR is an important task to overall economy of direct coal liquefaction. This paper studies hydro-treatment of a DCLR and its solvent-extraction components under typical direct coal liquefaction conditions. The DCLR is found hydro-treatable, resulting in more light products and less heavy products. In one case, 40 wt% heavy fractions in the DCLR are converted into light fractions. Hexane soluble fraction (HS) is the most stable while pre-asphaltene fraction is the most active during the hydro-treatment. Some synergetic effect can be observed when DCLR is treated as whole. The fractions of DCLR, before and after the hydro-treatment, are subjected to FTIR and NMR analyses, which show increase in hydrogen content and decrease in oxygen content in HS fractions after the hydro-treatment. GPC analysis reveals that the hydro-treatment results in slight decreases in molecular weight of HS fraction. The data seem to suggest that separation and hydro-treatment of liquid fractions from a DCLR is a viable option for high oil yield.

08/02507 Multi-objective optimization for two catalytic membrane reactors – methanol synthesis and hydrogen production

Cheng, S.-H. *et al. Chemical Engineering Science*, 2008, 63, (6), 1428–1437.
This paper provides the triple-objective-function optimization results for the catalytic membrane reactors, including one for methanol synthesis and one for hydrogen generation. A 1-D, non-isothermal model, which takes into account the intra-particle diffusion for the catalyst, and the elitist non-dominated sorting genetic algorithm for the multi-objective optimization are adopted. Optimal solutions for methanol synthesis and hydrogen generation systems show distinctive feature. One is randomly scattered and the other is linearly spread out in the Pareto plot. Solution characteristics in terms of variable distribution are quite different for the two systems. Device size, including membrane area and membrane size, shows effects both on the optimal solutions and on the correlation relations between objective functions and variables.

08/02508 Single-event-lumped-parameter hybrid (SELPH) model for non-ideal hydrocracking of *n*-octane

Chavarría-Hernández, J. C. *et al. Catalysis Today*, 2008, 130, (2–4), 455–461.
Hydrocracking of normal octane was carried out at temperatures from 493 to 548 K and pressures of 15 and 35 bar. The experiments were performed on USY zeolite loaded with 0.25 wt.% Pt. The selected experimental conditions allowed a transition from ideal to non-ideal hydrocracking. Single-event kinetic rate constants were estimated in a first stage, using only the ideal-hydrocracking data and a single-event-ideal-hydrocracking model. The estimates of the first stage were used in a second stage in which a single-event-lumped-parameter hybrid (SELPH) model for non-ideal hydrocracking was used. The SELPH kinetic model was able to accurately describe the transition from ideal to non-ideal hydrocracking.

08/02509 Studies on the evolution of asphaltene structure during hydroconversion of petroleum residues

Gauthier, T. *et al. Catalysis Today*, 2008, 130, (2–4), 429–438.
The evolution of asphaltenes has been studied under hydroconversion conditions with an ebullated bed on a Buzurgan (Middle East) feedstock. A bench unit was used to produce effluents in residue conversion conditions ranging from 55 to 85 wt.%. In those conditions, asphaltene conversion ranged 62–89 wt.%. Asphaltenes from the feedstock and unconverted asphaltenes have been characterized using Size Exclusion Chromatography to evaluate asphaltene size, and ^{13}C Nuclear Magnetic Resonance to evaluate the evolution of the average molecular structure parameters of asphaltenes. Results obtained were compared to results obtained at moderate residue conversion levels in a fixed bed. The work clearly shows that unconverted asphaltene evolution is continuous. Unit size decreases with increasing conversion while the aromaticity of the asphaltenes increases due to dealkylation. The results suggest that the remaining asphaltenes are dissociated in smaller aggregates around 50% conversion. Below this level, asphaltene evolution may be related to dissociation mechanisms. Above 50% conversion, the chemical structure of asphaltene units still significantly evolves through dealkylation mechanisms, leading to fairly condensed structures that remain at high conversion. Based on these results, an attempt was conducted to interpret the evolution of unconverted asphaltenes as a function of residue conversion level using a simple molecular reconstruction method.

08/02510 Sulfur transfers from pyrolysis and gasification of direct liquefaction residue of Shenhua coal

Chu, X. *et al. Fuel*, 2008, 87, (2), 211–215.
The sulfur transformation during pyrolysis and gasification of Shenhua direct liquefaction residue was studied and the release of H_2S and COS during the process was examined. For comparison, the sulfur transfer of Shenhua coal during pyrolysis and that of pyrolysed char during gasification were also studied. The residue was pyrolysed at 10 °C/min to 950 °C. During pyrolysis about 33.6% of sulfur was removed from the residue, among which 32.1% was formed H_2S in gas and 1.5% was transferred into tar, 66.4% of the sulfur was remained in residue char. Compared with coal, the residue has generated more H_2S due to presence of $Fe_{1-x}S$ which was enriched in residue during liquefaction process. There is a few COS produced at 400–500 °C during pyrolysis of coal, but it was not detected form pyrolysis of the residue. During CO_2 gasification, compared with pyrolysis and steam gasification, there are more COS and less H_2S formation, because CO could react with sulfide to form COS. During steam gasification only H_2S was produced and no COS detected, because H_2 has stronger reducibility to form H_2S than CO. After steam gasification no sulfur was detected in the gasification residue. The XRD patterns show after steam gasification, only Fe_3O_4 is remained in the gasification residue. This indicates that the catalyst added during the liquefaction of coal completely reacted with steam, resulting in the formation of H_2 and Fe_3O_4.

08/02511 The role of CeO_2–ZrO_2 as support in the ZnO–$ZnCr_2O_4$ catalysts for autothermal reforming of methanol

Liu, N. *et al. Fuel Processing Technology*, 2008, 89, (6), 574–581.

Autothermal reforming of methanol for hydrogen production was investigated over $ZnO–ZnCr_2O_4$ supported on a series of metal oxides (Al_2O_3, CeO_2, ZrO_2 and $CeO_2–ZrO_2$). $CeO_2–ZrO_2$ mixed oxides with Ce /Zr molar ratio of 4/1 was found to be the optimal support which showed significant effect on the catalytic activity and selectivity. The $ZnO–ZnCr_2O_4/CeO_2–ZrO_2$ and $ZnO–ZnCr_2O_4$ catalysts were characterized by XRD, TEM, H_2-TPR and XPS. The results show that $CeO_2–ZrO_2$ mixed oxides have significant effect on the catalytic performance and the supported catalyst shows more uniform temperature distribution in the catalyst bed which was mainly due to its reasonable redox properties.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

08/02512 A rapid compression machine study of the oxidation of propane in the negative temperature coefficient regime

Gallagher, S. M. *et al. Combustion and Flame*, 2008, 153, (1–2), 316–333.

The oxidation of propane has been studied in the temperature range 680–970 K at compressed gas pressures of 21, 27, and 37 atm and at varying equivalence ratios of 0.5, 1.0, and 2.0. These data are consistent with other experiments presented in the literature for alkane fuels in that, when ignition delay times are plotted as a function of temperature, a characteristic negative coefficient behaviour is observed. In addition, these data were simulated using a detailed chemical kinetic model. It was found that qualitatively the model correctly simulated the effect of change in equivalence ratio and pressure, predicting that fuel-rich, high-pressure mixtures ignite fastest, while fuel-lean, low-pressure mixtures ignite slowest. Moreover, reactivity as a function of temperature is well captured, with the model predicting negative temperature coefficient behaviour similar to the experiments. Quantitatively the model is faster than experiment for all mixtures at the lowest temperatures (650–750 K) and is also faster than experiment throughout the entire temperature range for fuel-lean mixtures.

08/02513 Comparison of hydrocarbon gases (C_1–C_5) production from Carboniferous Donets (Ukraine) and Cretaceous Sabinas (Mexico) coals

Alsaab, D. *et al. International Journal of Coal Geology*, 2008, 74, (2), 154–162.

The objecitve of this contribution is to compare the ability of Carboniferous coals from the Donets Basin of the Ukraine and Cretaceous coal from the Sabinas Basin of the Mexico to generate hydrocarbon gases (C_1–C_5). Two bituminous coals from the Donets Basin (2c10YD and 111Dim; 0.55 and 0.65%R_r respectively) and one bituminous coal from the Sabinas Basin (Olmos, 0.92%R_r) were studied using heating experiments in a confined-pyrolysis system. The highest rank reached during the heating experiments corresponds to the anthracite stage (2.78 and 2.57%R_r) for the 2c10YD and 111Dim coals and (2.65%R_r) for the Olmos coal. The composition of the generated (C_1–C_5) gases was evaluated using a thermodesorption-multidimensional gas chromatography. The results show that the Carboniferous Donets coals produced more wet gas and methane during pyrolysis than the Cretaceous Olmos coal. This is probably due to their higher liptinite (6–20%) and collodetrinite content and to the loss of a major part of the petroleum potential of the Olmos coal during natural coalification. C_2–C_5 compounds are mainly derived from the cracking of liquid hydrocarbons. Ethane is the most stable compound and formed from the cracking of higher hydrocarbon component. Large amounts of methane (up to 81 mg/g coal for the Donets coals and 50 mg/g coal for the Sabinas coal) were formed at high temperatures by cracking of previously formed heavier hydrocarbons and by dealkylation of the coal matrix. A linear relationship was observed between methane generation and the maturity level of both coal types.

08/02514 Differential swelling and permeability change of coal in response to CO_2 injection for ECBM

Mazumder, S. and Wolf, K. H. *International Journal of Coal Geology*, 2008, 74, (2), 123–138.

The matrix volume of coal swells when CO_2/CH_4 adsorb on the coal structure. In coalbed gas reservoirs, matrix swelling could cause the fracture aperture width to decrease, causing a considerable reduction in permeability. On a unit concentration basis, CO_2 causes greater degree of coal matrix swelling compared to CH_4. Much of this difference is attributable to the differing sorption capacity that coal has towards carbon dioxide and methane. This condition in a coal reservoir would lead to differential swelling. Differential swelling will have consequences in terms of porosity/permeability loss, with serious implication for the performance and implementation of carbon sequestration projects. Coal can be understood as a macromolecular cross-linked polymeric structure. An experimental effort has been made to measure the differential swelling effect of CO_2/CH_4 on this macromolecular structure and to theoretically translate that effect in terms of porosity and permeability. A unique feature of this work is that, real time permeability measurements were done to see the true effect of differential strain from CH_4 saturated coal core flooding experiments.

08/02515 Laminar burning velocity and explosion index of LPG–air and propane–air mixtures

Huzayyin, A. S. *et al. Fuel*, 2008, 87, (1), 39–57.

The determination of burning velocity is very important for the calculations used in hazardous waste explosion protection and fuel tank venting, which has a direct impact on environmental protection. The scope of the present study encompass an extensive study to map the variations of the laminar burning velocity and the explosion index of liquid petroleum gas (LPG)–air and propane–air mixtures over wide ranges of equivalence ratio ($\Phi = 0.7–2.2$) and initial temperature ($T_i = 295–400\,K$) and pressure ($P_i = 50–400\,kPa$). For this purpose a cylindrical combustion bomb was developed. The reliability and accuracy of the built up facility together with the calculation algorithm are confirmed by comparing the values of the laminar burning velocity obtained for a standard fuel (propane at normal pressure normal temperature conditions, NPT) with those available in the literature. The burning velocity was determined using different models depending on the pressure history ($P–t$) of the central ignition combustion process at the minimum ignition energy. The data obtained for the laminar burning velocity is correlated to $S_L = S_L(T/T_0)^{\alpha}(P/P_0)^{\beta}$ where S_{L0} is the burning velocity at NPT, α and β are the temperature and pressure exponents respectively. The value of β is observed to slightly vary with the equivalence ratio for both fuels. However, propane exhibits higher pressure dependency than that of LPG. The maximum laminar burning velocity found for propane is nearly 455 mm/s at $\Phi = 1.1$, while that for LPG is nearly 432 mm/s at 4.5% fuel percent ($\Phi \approx 1.5$). The maximum explosion index, commonly called the 'explosion severity parameter', is calculated from the determined laminar burning velocity and is found to be 93 bar m/s for propane, and nearly 88 bar m/s for LPG.

08/02516 The use of numerical simulation in predicting coalbed methane producibility from the Gates coals, Alberta Inner Foothills, Canada: comparison with Mannville coal CBM production in the Alberta Syncline

Gentzis, T. and Bolen, D. *International Journal of Coal Geology*, 2008, 74, (3–4), 215–236.

Two medium to low volatile bituminous rank coals in the Lower Cretaceous Gates Formation (Mannville equivalent), Inner Foothills of Alberta, were cored as part of a coalbed methane exploration program. The target seams (Seam 4 and Seam 10) were intersected at 652 m and 605 m, respectively. The coals were bright banded, relatively competent and reasonably cleated, with cleat spacing between 5–20 mm. The formation micro-imaging log identified two primary fracture directions, corresponding to both face and butt cleats, which were developed almost equally in some coal intervals. The amount of shearing was limited, in spite of the presence of numerous thrust faults and fold structures in the corehole vicinity. Total gas content was high, with an average of 17.7 cm^3/g (arb; 568.1 scf/t). An adsorption isotherm of the thick Seam 4 showed gas saturation levels of 90% at *in situ* reservoir conditions. Methane content was 92–96% and carbon dioxide levels were less than 2%. Isotopic studies on the methane confirmed the thermogenic origin of the gas, as anticipated based on the coal rank. The coal seams were fracture stimulated using 50/50 nitrogen and fresh water along with 9 to 12 tons of 12/20 mesh sand used as a proppant. It is believed that the coals were not stimulated properly because of the small proppant volume and the complex – and often unpredictable – fracture pattern in coals, particularly in the Inner Foothills region that has high stress anisotropy. An injectivity test showed coal absolute permeability to be less than 1 mD, the skin to be −2 (indicating a slightly damaged coal) and water saturation in the cleats to be 90%. A four-month production test was conducted; gas rates declined from 930 to 310 m^3/d (33 to 11 MCFD) and water rates were low (< 5 BWD). Produced water was saline (TDS was 20,000 mg/L) and high in chloride and bicarbonate ions. Production testing was followed by history matching and numerical simulation, which consisted of numerous vertical and horizontal well development scenarios and other parameters. Simulating multiple parallel horizontal wells in the Gates coals resulted in the highest peak gas production rates, cumulative production and recovery efficiencies, in agreement with public data from the Mannville coals in the deeper part of the Alberta Syncline.

The positive effect of constructive interference in depressurizing the coal reservoirs and accelerating gas production over short periods of time was demonstrated. Coal quality data from a nearby underground mine shows that drilling horizontal wellbores in the Gates coals would be challenging because of unfavourable geomechanical properties, such as low cohesion and unconfined compressive strength values, and structural complexity.

08/02517 Thermodynamics of fuels with a biosynthetic component (III): vapor–liquid equilibrium data for the ternary mixture ethyl 1,1-dimethylethyl ether, *n*-heptane and 1-hexene at $T = 313.15$ K

Villamañán, R. M. *et al. Fluid Phase Equilibria*, 2008, 265, (1–2), 12–16.

Accurate vapour–liquid equilibria were measured for the ternary system ethyl 1,1-dimethylethyl ether + *n*-heptane + 1-hexene using an isothermal total pressure cell. The experimental data were well correlated using Wohl expansion and Wilson, NRTL and UNIQUAC models. The system shows a slight positive deviation from the ideality. A comparison with similar ternary systems containing other ethers is also discussed in the paper.

Transport, storage

08/02518 An engineering-economic model of pipeline transport of CO_2 with application to carbon capture and storage

McCoy, S. T. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (2), 219–229.

Carbon dioxide capture and storage (CCS) involves the capture of CO_2 at a large industrial facility, such as a power plant, and its transport to a geological (or other) storage site where CO_2 is sequestered. Previous work has identified pipeline transport of liquid CO_2 as the most economical method of transport for large volumes of CO_2. However, there is little published work on the economics of CO_2 pipeline transport. The objective of this paper is to estimate total cost and the cost per tonne of transporting varying amounts of CO_2 over a range of distances for different regions of the continental United States. An engineering-economic model of pipeline CO_2 transport is developed for this purpose. The model incorporates a probabilistic analysis capability that can be used to quantify the sensitivity of transport cost to variability and uncertainty in the model input parameters. The results of a case study show a pipeline cost of US\$ 1.16 per tonne of CO_2 transported for a 100 km pipeline constructed in the Midwest handling 5 million tonnes of CO_2 per year (the approximate output of an 800 MW coal-fired power plant with carbon capture). For the same set of assumptions, the cost of transport is US\$ 0.39 per tonne lower in the Central US and US\$ 0.20 per tonne higher in the Northeast US. Costs are sensitive to the design capacity of the pipeline and the pipeline length. For example, decreasing the design capacity of the Midwest US pipeline to 2 million tonnes per year increases the cost to US\$ 2.23 per tonne of CO_2 for a 100 km pipeline, and US\$ 4.06 per tonne CO_2 for a 200 km pipeline. An illustrative probabilistic analysis assigns uncertainty distributions to the pipeline capacity factor, pipeline inlet pressure, capital recovery factor, annual O&M cost, and escalation factors for capital cost components. The result indicates a 90% probability that the cost per tonne of CO_2 is between US\$ 1.03 and US\$ 2.63 per tonne of CO_2 transported in the Midwest US. In this case, the transport cost is shown to be most sensitive to the pipeline capacity factor and the capital recovery factor. The analytical model elaborated in this paper can be used to estimate pipeline costs for a broad range of potential CCS projects. It can also be used in conjunction with models producing more detailed estimates for specific projects, which requires substantially more information on site-specific factors affecting pipeline routing.

08/02519 Carbon dioxide storage potential of shales

Busch, A. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (3), 297–308.

Options for the geologic storage of carbon dioxide vary from saline aquifers and depleted oil and gas reservoirs to unminable coal seams and abandoned coal mines. Important aspects include the sealing integrity of the cap rock and potential changes in this integrity, owing to the interaction with CO_2. In this study, diffusive transport and gas sorption experiments on one well characterized shale sample (Muderong Shale, Australia) and different clay minerals were performed to obtain information on the sealing integrity and the CO_2 storage potential of these materials. All measurements were performed under reservoir conditions relevant for CO_2 storage ($T = 45$–$50\,^\circ$C; $p < 20$ MPa). Repeat diffusion experiments on one shale plug yielded increased effective diffusion coefficients and a decrease in the concentration of the bulk CO_2 volume in the sample. The latter is believed to be dissolved in formation water, sorbed to mineral surfaces or involved with geochemical reactions. For the Muderong Shale, bulk volume CO_2 concentrations are greater within the experimental time frame (222–389 mol/m^3), when compared to coal and cemented sandstone (3–4 and 8–10 mol/m^3), respectively. This high CO_2 storage potential could not fully be explained by CO_2 dissolution in water alone. Thus, gas sorption experiments were performed on crushed shale and various clay minerals. High CO_2 sorption capacities (e.g. up to 1 mmol/g for the Muderong Shale) show that the high CO_2 concentration is related to a combination of CO_2 dissolution in water and gas sorption on clay minerals. Additionally, changes in specific surface areas before and after the sorption experiments and variations in the CO_2 sorption and diffusion behaviour due to repetitive experiments on the identical sample were observed, possibly related to geochemical alteration of the Muderong Shale and the clay minerals. These could not be quantified however and seemed to occur only at high pressures. Results obtained in this study provide a more positive view on the sealing integrity of intact cap rock formations. Carbon dioxide that migrates from a storage reservoir into the cap rock through the pore network will be immobilized to a certain extent, hence minimizing (slow, diffusion-driven) leakage and providing additional CO_2 storage potential.

08/02520 Coalbed methane producibility from the Mannville coals in Alberta, Canada: a comparison of two areas

Gentzis, T. *et al. International Journal of Coal Geology*, 2008, 74, (3–4), 237–249.

The Mannville coals in the Fenn area, Alberta Plains, have desorbed gas content averaging 8.57 cm^3/g (275 scf/t), which is similar to the same coals in the Corbett Creek area, almost 400 km away. Vitrinite reflectance values are also similar, although the coals at Corbett Creek are situated about 300 m shallower, which points to a rank excursion from Hilt's burial law curves at Corbett Creek. Coals from both areas are within the 'oil window'. The Medicine River Seam in the Fenn area has higher total inertinite content and greater proportions of inertodetrinite and detrovitrinite, suggesting that peat deposition occurred in swamps and marshes and were prone to periodic flooding. At Corbett Creek, the Mannville coal seams are characterized by greater concentrations of telo-inertinite, which contributes to coal meso-porosity and the potential for free gas storage in the open cell lumens, and to an increased gas flow along lithotype boundaries (horizontal permeability). Non-fluorescing vitrinite was present mostly in the Upper Medicine River Seam, which was deposited in a regressive environment. The Lower Medicine River Seam, which formed during a marine transgressive phase, contained greater amounts of fluorescing vitrinite. The Mannville coals in the Fenn area are moderately underpressured in relation to those at Corbett Creek, which may have an impact on gas retention capacity. The difference in absolute coal permeability (1–3.5 mD at Fenn versus 3–4 mD at Corbett Creek), which is likely the result of higher in-situ stresses in the deeper Mannville coals at Fenn, has had an effect on both gas and water production rates from these coals. However, the largest impact on gas production volumes has been made by the application of horizontal drilling technology, initially at Fenn, and more recently by multiple horizontal wells drilled at Corbett Creek.

08/02521 Implications of generator siting for CO_2 pipeline infrastructure

Newcomer, A. and Apt, J. *Energy Policy*, 2008, 36, (5), 1776–1787.

The location of a new electric power generation system with carbon capture and sequestration (CCS) affects the profitability of the facility and determines the amount of infrastructure required to connect the plant to the larger world. Using a probabilistic analysis, the authors examine where a profit-maximizing power producer would locate a new generator with carbon capture in relation to a fuel source, electric load, and CO_2 sequestration site. Based on models of costs for transmission lines, CO_2 pipelines, and fuel transportation, it is found that it is always preferable to locate a CCS power facility nearest the electric load, reducing the losses and costs of bulk electricity transmission. This result suggests that a power system with significant amounts of CCS requires a very large CO_2 pipeline infrastructure.

08/02522 Methane/natural gas storage and delivered capacity for activated carbons in dry and wet conditions

Najibi, H. *et al. Fuel*, 2008, 87, (1), 7–13.

Methane/natural gas storage and delivered capacity for three different activated carbons in dry and wet conditions were measured. In all tests the temperature of the bed was maintained constant at 277.15 K and pressure was increased up to 10 MPa. Natural gas storage capacity was less than methane storage capacity in dry conditions for all the three activated carbons tested, while the gas delivery was almost the same. One of activated carbon tested (NC120) showed the possibility of hydrate forming for pressures higher than 4 MPa but the amount of gas stored still was less than the amount stored in dry conditions over the whole range of pressure. The analysis of the gas delivered at each pressure steps shows that considerable amount of heavy components do not come out from the bed even at very low pressures in both dry and wet condition tests. Repeatability of the sorption/desorption processes – vital for possible commercial/industrial use – has been examined over various cycles.

08/02523 Non-isothermal flow of carbon dioxide in injection wells during geological storage

Lu, M. and Connell, L. D. *International Journal of Greenhouse Gas Control*, 2008, 2, (2), 248–258.

During sequestration, carbon dioxide within injection wells is likely to be in a dense state and therefore its weight within the wellbore will play an important role in determining the bottomhole pressure and thus the injection rate. However, the density could vary significantly along the well in response to the variation in pressure and temperature. A numerical procedure is formulated in this paper to evaluate the flow of carbon dioxide and its mixtures in non-isothermal wells. This procedure solves the coupled heat, mass and momentum equations with the various fluid and thermodynamic properties, including the saturation pressure, of the gas mixture calculated using a real gas equation of state. This treatment is particularly useful when dealing with gas mixtures where experimental data on mixture properties are not available and these must be predicted. To test the developed procedure two wellbore flow problems from the literature, involving geothermal gradients and wellbore phase transitions are considered; production of 97% carbon dioxide and injection of superheated steam. While these are not typical carbon dioxide injection problems they provide field observations of wellbore flow processes which encompass the mechanisms of interest for carbon dioxide injection, such as phase transition, temperature and density variations with depth. These two examples show that the developed procedure can offer accurate predictions. In a third application the role of wellbore hydraulics during a hypothetical carbon dioxide injection application is considered. The results obtained illustrate the potential complexity of carbon dioxide wellbore hydraulics for sequestration applications and the significant role it can play in determining the well bottomhole pressure and thus injection rate.

08/02524 Temperature fields of the extruded pipe under conditions of co-current cooling

Élesztös, P. and Écsi, L. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 969–972.

This article examines the temperature fields of the thick wall pipe while cooling it under the process of extrusion. The Fourier–Kirchhoff equation was solved by Fourier method in the form of an infinite row and with the help of Bessel's functions. The equations were transformed into dimensionless forms and a solution of during heat the authors got as the function of Biot's and Fourier's number, dimensionless inner radius and thermal capacitance ratio of contact phases.

08/02525 The change in effective stress associated with swelling during carbon dioxide sequestration on natural gas recovery

Zarębska, K. and Ceglarska-Stefańska, G. *International Journal of Coal Geology*, 2008, 74, (3–4), 167–174.

The sequestration of CO_2 by pumping it into deep coal seams is being investigated. It is therefore worthwhile to gather the information available on the interactions of CO_2 with coals and the effects of CO_2 on coals' properties in order to attempt a prediction of the long-term effects of sequestration. In the experiment, the volumetric changes of the coal matrix were monitored for a low-rank coal (C^{daf} 84.14; V^{daf} 33.4) for mixtures of CO_2 and CH_4 of different proportions and single gases. In the case of the sorption of a mixture of gases, the course of the kinetics of expansion of the coals studied indicates a lack of visible deformation of the coal structure. The observed phenomenon of a higher affinity to CO_2 and displacement of CH_4 by this sorbate may, provide one of the reasons for abrupt disturbances in the rock, by changes in the bed permeability, caused by competitive processes of sorption and desorption.

Economics, business, marketing, policy

08/02526 Deliverability and regional pricing in U.S. natural gas markets

Brown, S. P. A. and Yücel, M. K. *Energy Economics*, 2008, 30, (5), 2441–2453.

During the 1980s and early 1990s, interstate natural gas markets in the United States made a transition away from the regulation that characterized the previous three decades. With abundant supplies and plentiful pipeline capacity, a new order emerged in which freer markets and arbitrage closely linked natural gas price movements throughout the country. After the mid-1990s, however, US natural gas markets tightened and some pipelines were pushed to capacity. The authors look for the pricing effects of limited arbitrage through causality testing between prices at nodes on the US natural gas transportation system and interchange prices at regional nodes on North American electricity grids. The tests do reveal limited arbitrage, which is indicative of bottlenecks in the US natural gas pipeline system.

08/02527 Energy, economic and environmental performance of heating systems in Greek buildings

Papadopoulos, A. M. *et al*. *Energy and Buildings*, 2008, 40, (3), 224–230.

The introduction of natural gas in the Greek energy market broadened the options in the field of space heating. Residents in five major Greek cities can choose from a variety of different fuels and systems for heating their houses or working spaces; 12 more cities will be connected to the gas network within the next 5 years. Considering that space heating is the major energy consuming activity in the Greek building sector and that the environmental constrains imposed by the Kyoto protocol will be met only with difficulty, if at all, a strategy concerning the developments in space heating seems to be necessary. This however presupposes an elaborate analysis of the overall performance of the alternative systems, taking into consideration the particular conditions of the Greek energy system and the 'established' way of designing residential and mixed-use buildings. The present paper aims to present the empirical comparative results related to the three most popular heating systems operated in Greek multi-apartment and mixed-use buildings, which use three different fuels, respectively: a central oil-fired boiler, a unitary gas-fired boiler and unitary heat pumps.

08/02528 Future evolution of the liberalised European gas market: simulation results with a dynamic model

Lise, W. and Hobbs, B. F. *Energy*, 2008, 33, (7), 989–1004.

Strategic behaviour by gas producers is likely to affect future gas prices and investments in the European Union (EU). To analyse this issue, a computational game theoretic model is presented that is based on a recursive-dynamic formulation. This model addresses interactions among demand, supply, pipeline and liquefied natural gas (LNG) transport, storage and investments in the natural gas market over the period 2005–2030. Three market scenarios are formulated to study the impact of producer market power. In addition, tradeoffs among investments in pipelines, LNG liquefaction and regasification facilities, and storage are explored. The model runs indicate that LNG can effectively compete with pipelines in the near future. Further, significant decreases in Cournot prices between 2005 and 2010 indicate that near-term investments in EU gas transport capacity are likely to diminish market power by making markets more accessible.

08/02529 Investment decisions in electricity transmission in Argentina: the role of earmarked funds and gas pipeline expansions

Chisari, O. O. and Romero, C. A. *Energy Economics*, 2008, 30, (4), 1321–1333.

This paper re-examines the problem of collective decisions of investment in electricity transmission in Argentina in the 1990s. The previous results are summarized on the existence of a fundamental flaw in the evaluation of willingness-to-pay and on the need to consider the votes of groups of generators integrated through common ownership rather than individual generators. The authors discuss the workings of the SALEX account for financing expansions and confirm that the imperfect identification of voters could affect the evaluation of expansion projects. An integrated model is also studied that considers two alternatives to electricity transmission: gas transmission and the location of generators; it is shown that location in the demand node voting against expansions in electricity transmission could be justified to maximize profits.

08/02530 Risk premium in the UK natural gas forward market

Haff, I. H. *et al*. *Energy Economics*, 2008, 30, (5), 2420–2440.

This report investigates the UK natural gas market, and tests whether it is a fair-game efficient forward market, using forward contracts ranging from 1 to 5 months time to delivery. The forward and spot price series are separately non-stationary, but cointegrated. Furthermore, the forward prices are biased predictors of both the future spot and the 1-month-ahead forward price. The risk premium on the forward prices is positive, as opposed to the US gas market, where the risk premium was found to be negative in similar work. Moreover, the analysis reveals that the storage model is an incomplete model for the relationship between the spot and forward prices. However, storage has a clear effect on this relationship, an effect that appears to be non-linear.

08/02531 The competitiveness of Korea as a developer of hydrogen energy technology: the AHP approach

Lee, S. K. *et al. Energy Policy*, 2008, 36, (4), 1284–1291.

Korea's need for energy conservation and alternative energy is greater than for any other nation. Korea imports more than 97% of its total energy consumption and ranks in tenth position in the world in terms of energy consumption. Developing hydrogen energy technology has great potential to cope with Korea's energy security and to establish Korea's hydrogen economy. In this study, the authors analysed the potential of Korea to be competitive in development of hydrogen energy technology using the analytic hierarchy process (AHP) approach. In this paper, two scenario analyses are presented: in the first, the research and development budget is a criterion and in the second it is not. The results show that Korea is the sixth most competitive nation because of the low score for infrastructure required for hydrogen technology. In addition, compared with US results for both scenarios, patents, papers and proceedings, research and development budgets, and infrastructure for hydrogen technology are inferior to the US, which is ranked in first place for this sector. Korean policymakers have to concentrate on those sectors to strengthen Korea's competitiveness in the development of hydrogen energy technology.

08/02532 The potential role of hydrogen energy in India and Western Europe

van Ruijven, B. *et al. Energy Policy*, 2008, 36, (5), 1649–1665.

In this paper, the TIMER energy model is used to explore the potential role of hydrogen in the energy systems of India and Western Europe, looking at the impacts on its main incentives: climate policy, energy security and urban air pollution. It is found that hydrogen will not play a major role in both regions without considerable cost reductions, mainly in fuel cell technology. Also, energy taxation policy is essential for hydrogen penetration and India's lower energy taxes limit India's capacity to favour hydrogen. Once available to the (European) energy system, hydrogen can decrease the cost of CO_2 emission reduction by increasing the potential for carbon capture technology. However, climate policy alone is insufficient to speed up the transition. Hydrogen diversifies energy imports; especially for Europe it decreases oil imports, while increasing imports of coal and natural gas. For India, it provides an opportunity to decrease oil imports and use indigenous coal resources in the transport sector. Hydrogen improves urban air quality by shifting emissions from urban transport to hydrogen production facilities. However, for total net emissions the authors found a sensitive trade-off between lower emissions at end-use (in transport) and higher emissions from hydrogen production, depending on local policy for hydrogen production facilities.

Derived gaseous fuels

08/02533 A unified model for top fired methane steam reformers using three-dimensional zonal analysis

Zamaniyan, A. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 946–970.

Mathematical modelling of top-fired steam reforming reactor and its furnace is presented. For the reactor side one-dimensional heterogeneous model with mass transfer limitation in catalyst pellets was considered. A three-dimensional zonal analysis was used in the furnace side for heat transfer modelling. Results from literature and data from an industrial top fired steam reformer were used to validate the model. Effects of important design and process parameters were studied using the combined model. A maximum temperature in external tube skin was observed in one third of the reactor length from top. It was shown that a 20% rise in effective emissivity of tubes leads to an increase of approximately 3.5% in reactor exit temperature. In addition reduction of extinction coefficients of combustion gases by 25% leads to about 2.6% rise in temperature.

08/02534 Can the future EU ETS support wind energy investments?

Blanco, M. S. and Rodrigues, G. *Energy Policy*, 2008, 36, (4), 1509–1520.

This article discusses how the future emissions trading scheme (ETS) legislation should be designed to allow the European Union (EU) to comply with the 20% CO_2 emissions reduction target, while at the same time promoting wind energy investments. The paper considers whether CO_2 prices could eventually replace the existing support schemes for wind and if they adequately capture its benefits. This analysis also looks at the effectiveness of the clean development and joint implementation mechanisms to trigger wind projects and technology transfer in developing countries. It is discovered that climate policy is unlikely to provide sufficient incentives to promote wind power, and that other policies should be used to internalize the societal benefits that accrue from deploying this technology: CO_2 prices can only reflect the beneficial impact of wind on climate change but not its contribution to the security of supply or employment creation. A minimum price of around €40/tCO_2 should be attained to maintain present support levels for wind and this excludes income risks and intermediation costs. Finally, the clean development mechanism improves the return rate of wind energy projects in third countries, but it is the local institutional framework and the long-term stability of the CO_2 markets that matters the most.

08/02535 Experimental studies on hydrogen generation by methane autothermal reforming over nickel-based catalyst

Wang, H. M. *Journal of Power Sources*, 2008, 177, (2), 506–511.

This paper presents the experimental studies on the hydrogen generation by methane autothermal reforming method. An experimental system was built in-house for this study. The temperature profile along the axis of the reformer was measured and discussed. The peak temperature of the reformer appeared in the part of 1/4 to 2/4 of the reformer length from inlet to outlet. The maximum hydrogen yield, hydrogen mole numbers generated per mole of methane consumed of 2.71, was achieved at molar oxygen-to-carbon ratio of 1.68 and molar steam-to-carbon ratio of 2.5. Under this condition, the energy conversion efficiency of the reforming process reached 81.4% based on the lower heating values.

08/02536 Future European gas supply in the resource triangle of the Former Soviet Union, the Middle East and Northern Africa

Remme, U. *et al. Energy Policy*, 2008, 36, (5), 1622–1641.

A steady increase of natural gas demand can be observed in Europe over the last few decades. Due to the European obligation to reduce greenhouse gas emissions in the framework of the Kyoto Protocol, the trend toward natural gas is expected to continue in the future. The increased consumption is faced by comparably low indigenous gas resources within Europe, so that the dependency of Europe on gas imports from abroad will rise in the future. In addition to the existing supply sources Russia and Algeria, gas resources from the Middle East and the Caspian and the Central Asian regions may be supply options to cover Europe's gas demand in the future. Against this background, possible natural gas supply options as well as the transport infrastructure to and within Europe are discussed regarding their technical capacity and their costs. With the help of a cost-minimization model of the European gas supply system, the gas flows and the infrastructure capacity development up to the year 2030 are analysed. In a sensitivity analysis, the impacts of demand variations on the choice of supply sources are studied.

08/02537 Green vs. green: measuring the compensation required to site electrical generation windmills in a viewshed

Groothuis, P. A. *et al. Energy Policy*, 2008, 36, (4), 1545–1550.

Proponents of wind power note that wind is a green energy source. Yet locating electrical generating windmills has become difficult in some localities because of potential negative externalities. The authors address why the not-in-my-backyard (NIMBY) syndrome may arise when choosing site locations by addressing the perceived property rights of a viewshed, the role of compensation in a NIMBY impasse, and how concerns for the environment might lessen the compensation required. A willingness to accept framework is used to measure the compensation required to allow wind generation windmills to be built in the mountains of North Carolina. It is found that individuals who perceive wind energy as a clean source of power require less compensation. Those who retire to the mountains or individuals who have ancestors from Watauga County require more compensation to accept windmills in their viewshed. In addition, the authors find in a bivariate-probit analysis that individuals who are more likely to participate in a green energy program are also more likely to allow electrical generation windmills in their viewshed, suggesting that the green vs. green environmental debate is overstated.

08/02538 Laboratory simulated slipstream testing of novel sulfur removal processes for gasification application

Schmidt, R. *et al. Fuel Processing Technology*, 2008, 89, (6), 589–594.

The Wabash River integrated methanol and power production from clean coal technologies project is investigating an early entrance coproduction plant concept to evaluate integrated electrical power generation and methanol production from coal and other carbonaceous feedstocks. Research, development and testing that is currently being conducted under the project is evaluating cost effective process systems for removing contaminants, particularly sulfur species, from the generated gas which contains mainly synthesis gas (syngas), CO_2 and steam at concentrations acceptable for the methanol synthesis catalyst.

The RD&T includes laboratory testing followed by bench-scale and field testing at the SG Solutions Gasification Plant located in West Terre Haute, Indiana. Actual synthesis gas produced by the plant was utilized at system pressure and temperature for bench-scale field testing. ConocoPhillips Company developed a sulfur removal technology based on a novel, regenerable sorbent – S Zorb^{TM} – to remove sulfur contaminants from gasoline at high temperatures. The sorbent was evaluated for its sulfur removal performance from the generated syngas especially in the presence of other components such as water and CO_2 which often cause sorbent performance to decline over time. This publication also evaluates the performance of a regenerable activated carbon system developed by Nucon International, Inc. in polishing industrial gas stream by removing sulfur species to parts-per-billion levels.

08/02539 Preparation and characterization of Ir/TiC catalyst for oxygen evolution

Ma, L. *et al. Journal of Power Sources*, 2008, 177, (2), 470–477.

Nano-sized titanium carbide (TiC) was employed as the support material for an iridium (Ir) electrocatalyst in a proton exchange membrane water electrolyser (PEMWE). The Ir/TiC electrocatalyst for the oxygen evolution reaction (OER) was prepared by chemical reduction and deposition with ultrasonic dispersion. The diameter of the Ir particles deposited on the TiC support is 10–40 nm. The Ir/TiC catalyst has a pore volume of $0.1425\,cm^3\,g^{-1}$, which is about two times as high as that of the corresponding unsupported Ir. Scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD) and energy dispersive X-ray (EDX) analysis indicate that the Ir particles are nearly uniformly deposited on the surface of the TiC and exhibit remarkably fine variable crystallites and crystal lattice defects, which enhance the density of active sites and greatly improves the catalytic activity of the Ir/TiC catalyst. Cyclic voltammograms (CVs) reveal that the peak current density at 1.5 V versus SCE on the Ir/TiC is about nine times of that for the unsupported Ir black catalyst and potentiostatic analysis shows that the charge passed by the Ir/TiC after 600 s at 1.3 V versus SCE is about 15 times of that for the unsupported Ir catalyst. Electrochemical impedance spectroscopy (EIS) shows that the electrochemical polarization impedance of the Ir/TiC catalyst is about $50\,\Omega\,cm^2$ per 0.02 mg as compared to $150\,\Omega\,cm^2$ of the Ir black in the range of high frequency. The diffusion polarization impedances of the Ir/TiC form a semicircle and those of the Ir black are close to a straight line with a phase angle of 45° in the range of low frequency. Thus, the catalytic activity of the Ir/TiC for the OER is significantly higher than that of the unsupported Ir catalyst. The TiC support is chemically and electrochemically stable in the whole range of experimental potentials.

08/02540 Process simulation of natural gas steam reforming: fuel distribution optimisation in the furnace

Olivieri, A. and Vegliò, F. *Fuel Processing Technology*, 2008, 89, (6), 622–632.

This paper describes a two-step method to simulate the natural gas steam reforming for hydrogen production. The first step is to calculate reforming tube length and fuel distribution with equilibrium approach associated with heat transfer. The second step is to calculate and validate reforming performance with kinetic model. A short-cut simulation of hydrogen plant has also been performed to calculate inputs for the reformer model, such as total flow rate and composition of mixed fuel burning in the furnace chamber. Heat transfer, especially radiative heat transfer, is the key role in the steam reforming technology, due to the high heat fluxes involved. For this reason, energy modelling of the furnace chamber has been performed. The simulation evaluates the most important design variables, as tubes height, maximum tube-wall temperature, and tube pressure drop. The heat flux profile can be selected to have suitable metal temperatures to lengthen the reformer tube life. The model calculates the design parameters for reforming tube and fuel distribution among burners.

08/02541 TiO_2 promoted Co/SiO_2 catalysts for Fischer–Tropsch synthesis

Hinchiranan, S. *et al. Fuel Processing Technology*, 2008, 89, (4), 455–459.

The addition of small amount of TiO_2 to silica-supported cobalt catalysts significantly increasing the dispersion of cobalt and Co metallic surface area resulting in the remarkable enhancement of the Fisher–Tropsch synthesis (FTS) activity in the slurry-phase reaction. The addition of TiO_2 adjusted the interaction between cobalt and silica support quite well to realize the favourite dispersion and reduction degree of supported cobalt, leading to high catalytic activity in FTS. The properties of various catalysts were characterized by *in-situ* DRIFT, XRD, TPR, N_2 physisorption and H_2 chemisorption.

LNG

08/02542 Economic comparison between coal-fired and liquefied natural gas combined cycle power plants considering carbon tax: Korean case

Jeong, S.-J. *et al. Energy*, 2008, 33, (8), 1320–1330.

Economic growth is main cause of environmental pollution and has been identified as a big threat to sustainable development. Considering the enormous role of electricity in the national economy, it is essential to study the effect of environmental regulations on the electricity sector. This paper aims at making an economic analysis of Korea's power plant utilities by comparing electricity generation costs from coal-fired power plants and liquefied natural gas (LNG) combined cycle power plants with environmental consideration. In this study, the levelized generation cost method is used for comparing economic analysis of power plant utilities. Among the many pollutants discharged during electricity generation, this study principally deals with control costs related only to CO_2 and NO_2, since the control costs of SO_2 and total suspended particulates (TSP) are already included in the construction cost of utilities. The cost of generating electricity in a coal-fired power plant is compared with such cost in a LNG combined cycle power plant. Moreover, a sensitivity analysis with computer simulation is performed according to fuel price, interest rates and carbon tax. In each case, these results can help in deciding which utility is economically justified in the circumstances of environmental regulations.

Hydrogen generation and storage

08/02543 Electrochemical hydrogen pumping using a high-temperature polybenzimidazole (PBI) membrane

Perry, K. A. *et al. Journal of Power Sources*, 2008, 177, (2), 478–484.

Electrochemical hydrogen pumping using a high-temperature (>100 °C) polybenzimidazole (PBI) membrane was demonstrated under non-humidified and humidified conditions at ambient pressures. Relatively low voltages were required to operate the pump over a wide range of hydrogen flow rates. The advantages of the high-temperature capability were shown by operating the pump on reformate feed gas mixtures containing various amounts of CO and CO_2. Gas purity measurements on the cathode gas product were conducted and significant reductions in gas impurities were detected. The applicability of the PBI membrane for electrochemical hydrogen pumping and its durability under typical operating conditions were established with tests that lasted for nearly 4000 h.

08/02544 Hydrogen production through sorption-enhanced steam methane reforming and membrane technology: a review

Barelli, L. *et al. Energy*, 2008, 33, (4), 554–570.

Over the last years, interest in hydrogen as an energy carrier has significantly increased both for vehicle fuelling and stationary energy production from fuel cells. The benefits of a hydrogen energy policy are the reduction of the greenhouse effect, principally due to the centralization of the emission sources. Moreover, an improvement to the environmental benefits can be achieved if hydrogen is produced from renewable sources, as biomass. The present paper provides an overview of the steam methane reforming (SMR) process and methodologies for performances improvement such as hydrogen removal, by selective permeation through a membrane or simultaneous reaction of the targeted molecule with a chemical acceptor, and equilibrium shift by the addition of a CO_2 acceptor to the reactor. In particular, attention was focused on the sorption-enhanced SMR (SE-SMR) process in which sorbents are added in order to enhance the reactions and realize *in situ* CO_2 separation. The major operating parameters of SE-SMR are described by the authors in order to project and then realize the innovative carbonation reactor developed in previous studies.

08/02545 Hydrogen storage properties of Pd nanoparticle/carbon template composites

Campesi, R. *et al. Carbon*, 2008, 46, (2), 206–214.

Theoretical studies predict improved hydrogenation properties for hybrid carbon/metal composites. The hydrogen storage capacity of ordered porous carbon containing Pd clusters was measured. The C/Pd composite was obtained by chemical impregnation of an ordered porous carbon template (CT) with a H_2PdCl_4 solution followed by a reduction treatment. 10 wt.% of palladium clusters were introduced in the carbon porosity; the Pd clusters (2 nm in size) being homogeneously distributed. Thermodynamic hydrogenation properties of both

Pd-free CT and the Pd–10 wt.% CT composite have been determined by hydrogen isotherm sorption measurements and thermal desorption spectroscopy (TDS) analysis. The introduction of the palladium into the carbon matrix does not increase the hydrogen storage capacity at 77 K and 1.6 MPa, since here the hydrogen uptake is being attributed to physisorption on the carbon. However, at room temperature and moderate pressure (0.5 MPa), the filling of the CT with 10 wt.% nanocrystalline Pd results in an hydrogen uptake eight times larger than that of the Pd-free CT. After the second cycle, a good reversibility is observed. TDS measurements confirm that the sharp increase of the hydrogen uptake is due to the presence of the Pd clusters in the carbon porosity.

08/02546 Is cluster policy useful for the energy sector? Assessing self-declared hydrogen clusters in the Netherlands

Mans, P. *et al. Energy Policy*, 2008, 36, (4), 1375–1385.

Research on science-based industries has shown that it is important for organizations to be active in interorganizational networks. Cluster policy has been developed as a means to stimulate the development of these networks and thereby the success rate of these industries. Cluster policy is however not a common policy instrument in the energy sector. In this paper, the authors focus on three self-declared clusters active in hydrogen-related research and development in the Netherlands and address several characteristics of these clusters. It is concluded that cluster policy is a useful addition to existing energy research and development policies but that monitoring whether self-declared clusters actually function as clusters and what their contribution is to the overall system is pivotal in reaping the benefits of cluster policy.

08/02547 The reaction pathway and rate-limiting step of dehydrogenation of the $LiHN_2 + LiH$ mixture

Shaw, L. L. *et al. Journal of Power Sources*, 2008, 177, (2), 500–505.

The reaction pathway and rate-limiting step of dehydrogenation of the $LiNH_2 + LiH$ mixture have been investigated. The study reveals that dehydrogenation of the $LiNH_2 + LiH$ mixture is diffusion-controlled and the rate-limiting step is NH_3 diffusion through the Li_2NH product layer outside the $LiNH_2$ shrinking core. This phenomenon is explained based on a model describing the major steps of the dehydriding reaction of the mixture, and related to the evidence obtained from X-ray diffraction and specific surface area measurements of the mixture before and after isothermal hydrogen uptake/release cycles at high homologous temperatures.

04 BY-PRODUCTS RELATED TO FUELS

08/02548 Comparison of rapid and slow sintered pulverised fuel ash

Adell, A. *et al. Fuel*, 2008, 87, (2), 187–195.

This study has investigated the properties of sintered PFA using conventional (20 °C/min) and rapid heating rates. Rapid heating was achieved by directly placing pressed PFA samples into a furnace preset at the sintering temperature. Slow sintered PFA samples show an increase in shrinkage and fired density and a reduction in water absorption as the sintering temperature increases, with maximum density obtained at around 1250 °C. At higher temperatures samples show a bloating effect associated with the enlargement of closed porosity. This peak in density is not observed in rapidly sintered PFA. Rapid sintering at temperatures between 1150 °C and 1300 °C resulted in constant values of shrinkage (6.5%), fired density (1.4 g/cm^3) and water absorption (15%). During rapid sintering the residual carbon in the PFA is present in the sample at the sintering temperature whereas conventional sintering removes the carbon at lower temperatures before sintering occurs. Rapid sintering also retains significant carbon in the core of the sintered sample. This carbon is believed to act as rigid inclusions that inhibit PFA sintering, limiting shrinkage and densification. Rapid sintering is associated with black coring which is also characteristic in lightweight aggregate manufactured from PFA sintered on a sinter strand. The rapid heating rate experienced by PFA pellets on a sinter strand and the associated inhibition of sintering by carbon is essential for producing sintered PFA products with properties appropriate for use as lightweight aggregate.

08/02549 *In vitro* adsorption study of fluoxetine in activated carbons and activated carbon fibres

Valente Nabais, J. M. *et al. Fuel Processing Technology*, 2008, 89, (5), 549–555.

In this paper, the *in vitro* adsorption of fluoxetine hydrochloride is studied by different adsorbents in simulated gastric and intestinal fluid, pH 1.2 and 7.5, respectively. The tested materials were two commercial activated carbons, carbomix and maxsorb MSC30, one activated carbon fibre produced in the laboratory and also three MCM-41 samples, also produced by us. Selected samples were modified by liquid phase oxidation and thermal treatment in order to change the surface chemistry without significant modifications to the porous characteristics. The fluoxetine adsorption follows the Langmuir model. The calculated Q_0 values range from 54 to 1112 mg/g. A different adsorption mechanism was found for the adsorption of fluoxetine in activated carbon fibres and activated carbons. In the first case the most relevant factors are the molecular sieving effect and the dispersive interactions whereas in the activated carbons the mechanism seams to be based on the electrostatic interactions between the fluoxetine molecules and the charged carbon surface. Despite the different behaviours most of the materials tested have potential for treating potential fluoxetine intoxications.

08/02550 Mineralogical and elemental composition of fly ash from pilot scale fluidised bed combustion of lignite, bituminous coal, wood chips and their blends

Koukouzas, N. *et al. Fuel*, 2007, 86, (14), 2186–2193.

The chemical and mineralogical composition of fly ash samples collected from different parts of a laboratory and a pilot scale circulating fluidized bed facility has been investigated. The fabric filter and the second cyclone of the two facilities were chosen as sampling points. The fuels used were Greek lignite (from the Florina basin), Polish coal and wood chips. Characterization of the fly ash samples was conducted by means of X-ray fluorescence (XRF), inductive coupled plasma-optical emission spectrometry (ICP-OES), thermogravimetric analysis (TGA), particle size distribution (PSD) and X-ray diffraction (XRD). According to the chemical analyses the produced fly ashes are rich in CaO. Moreover, SiO_2 is the dominant oxide in fly ash with Al_2O_3 and Fe_2O_3 found in considerable quantities. Results obtained by XRD showed that the major mineral phase of fly ash is quartz, while other mineral phases that are occurred are maghemite, hematite, periclase, rutile, gehlenite and anhydrite. The ICP-OES analysis showed rather low levels of trace elements, especially for As and Cr, in many of the ashes included in this study compared to coal ash from fluidized bed combustion in general.

08/02551 Preparing and characterizing the active carbon produced by steam and carbon dioxide as a heavy oil hydrocracking catalyst support

Fukuyam, H. and Terai, S. *Catalysis Today*, 2008, 130, (2–4), 382–388.

Active carbon was prepared from Yallourn brown coal char using steam and carbon dioxide activation in a laboratory rotary kiln. The activation rate with steam was faster than that with carbon dioxide. The pore structure of the active carbons was characterized using the nitrogen isotherms at 77 K. The pore volume and specific surface area of the active carbon increased with the carbon burn-off, and compared to carbon dioxide, steam activation produced active carbon that was richer in mesopores by increasing the pore size from micropores to mesopores. The porosity of the active carbons was related to the ability to adsorb maltene, the normal hexane-soluble fraction, in the vacuum residue of petroleum crude. The steam-activated carbon rich in mesopores had a greater ability to adsorb maltene, which consists of large-molecular-weight hydrocarbons.

05 NUCLEAR FUELS

Scientific, technical

08/02552 Burnup analysis and in-core fuel management study of the 3 MW TRIGA MARK II research reactor

Huda, M. Q. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 141–147.

The principal objective of this study is to formulate an effective optimal fuel management strategy for the TRIGA MARK II research reactor at AERE, Savar. The core management study has been performed by utilizing four basic types of information calculated for the reactor: criticality, power peaking, neutron flux and burnup calculation. This paper presents the results of the burnup calculations for TRIGA LEU fuel elements. The fuel element burnup for approximately 20 years of operation was calculated using the TRIGAP compute code. The calculation is performed in one-dimensional radial geometry in TRIGAP. Inter-comparison of TRIGAP results with other two calculations performed by MVP-BURN and MCNP4C-ORIGEN2.1 show very good agreement. Reshuffling at 20,000 MWh step provides the highest core lifetime of the reactor, which is 64,500 MWh. Besides, the study gives valuable insight into the behaviour of the reactor and will ensure better utilization and operation of the reactor in future.

08/02553 Deuterium recovery from water–isotope mixture by thermal diffusion in countercurrent-flow Frazier scheme inclined for improved performance

Yeh, H.-M. *Fusion Engineering and Design*, 2008, 83, (4), 613–619.

The theory for recovery of deuterium from water isotope mixture by thermal diffusion in countercurrent-flow inclined Frazier scheme has been developed and investigated. The equations for the optimal angles of inclination and the corresponding best performances were derived. Considerable improvement in performance is obtained when the Frazier scheme is operated at the optimal angle of inclination. Further improvement can be achieved if the operation is conducted in countercurrent flow, instead of being in cocurrent flow.

08/02554 Experimental and modelling investigations of the biogeochemistry of gas production from low and intermediate level radioactive waste

Small, J. *et al. Applied Geochemistry*, 2008, 23, (6), 1383–1418.

The degradation of organic wastes and the corrosion of metallic wastes and steel containers in low and intermediate level radioactive waste (LLW/ILW) repositories are important processes that affect repository geochemistry and the speciation and transport of radionuclides. Gas is generated in association with these degradation processes and this has the potential to overpressure the repository, which can promote transport of groundwater and gas, and consequently radionuclide transport. Microbial activity plays an important role in organic degradation, corrosion and gas generation through the mediation of reduction–oxidation reactions. A large-scale gas generation experiment has been established at the LLW/ILW repository, Olkiluoto, Finland to examine gas generation from LLW in waste drums disposed of in the operational VLJ repository (VLJ is a Finnish acronym which translates to ‘reactor operating waste’). The experiment has monitored, for a period of 9 years, the rate and composition of gas generated, and the aqueous geochemistry and microbe populations present at various locations within the experiment. There is considerable heterogeneity within the experiment, such that pH is observed to vary from pH 5.5 to pH 10 between organic-rich waste and water associated with concrete. The heterogeneity results in competing anaerobic processes occurring together in the experiment but within different niches. Microbial activity initially dominant in organic waste has after 7 years reduced the alkalinity of the concrete influenced regions. The experiment has been modelled using a biogeochemical reaction-transport code (GRM) using a blind testing approach. Using independent data, the model was able to reproduce, within a factor of two, the rate of gas production. In addition, the model represented the main anaerobic microbial processes leading to methanogenesis and the observed spatial and temporal variations in aqueous and gaseous species. In order to model the experiment, its heterogeneity was considered such that individual waste containers were represented and assumptions were made concerning transport rates of chemical species. Cellulose waste and H_2 produced by corrosion provide microbial substrates for reduction processes and CH_4 generation. However, gas generation is a complex interaction of waste degradation processes. Simple repository gas generation models that consider corrosion and cellulose degradation in isolation will tend to overestimate H_2 content and gas generation. The GRM model is more realistic and utilises information concerning SO_4^{2-}, NO_3^- and other oxidized species present in LLW/ILW to consider the competition between microbial groups for electron donors that reduce the extent of H_2 and CH_4 generation. Models such as GRM could be applied to other repository systems, such as for high level waste and spent nuclear fuel, to evaluate how H_2 gas generation from corrosion and radiolysis may be affected by microbial activity. However, this will require estimation of appropriate microbial kinetic parameters for these more extreme environments.

08/02555 Fabrication of the KSTAR vacuum vessel and ports

Kim, B. C. *et al. Fusion Engineering and Design*, 2008, 83, (4), 573–579.

The construction of the steady-state-capable superconducting KSTAR tokamak is in close proximity to the finalization. As one of the main components of the KSTAR device, the vacuum vessel is designed and manufactured during the construction period. The KSTAR vacuum vessel is composed of two large sectors forming the 337.5° of a full torus, and the remaining 22.5° section consisting of 24 small pieces. The large two sectors were welded at the site, and the 22.5° space was used for toroidal field coil assembly. The remaining 22.5° section of the vacuum vessel was assembled after 16 toroidal field coils assembly. The total 72 penetration ports were used to connect the vacuum vessel body and the cryostat. The major fabrication activity started in January 2003 after the finalization of fabrication design. The final components and structures were warehoused in June 2004 and site assembly is finished in 2007. Details of analysis, shop fabrication, and inspection results of the vacuum vessel including ports are summarized in the present work.

08/02556 Feasibility study of boiling water reactor core based on thorium–uranium fuel concept

Núñez-Carrera, A. *et al. Energy Conversion and Management*, 2008, 49, (1), 47–53.

The design of a boiling water reactor (BWR) equilibrium core using the thorium–uranium (blanket–seed) concept in the same integrated fuel assembly is presented in this paper. The lattice design uses the thorium conversion capability to ^{233}U in a BWR spectrum. A core design was developed to achieve an equilibrium cycle of one effective full power year in a standard BWR with a reload of 104 fuel assemblies designed with an average ^{235}U enrichment of 7.5 w/o in the seed sub-lattice. The main core operating parameters were obtained. It was observed that the analysed parameters behave like those obtained in a standard BWR. The economic analysis shows that the fuel cycle cost of the proposed core design can be competitive with a standard uranium core design. Finally, a comparison of the toxicity of the spent fuel showed that the toxicity is lower in the thorium cycle than in other fuel cycles (UO_2 and MOX uranium and plutonium) in the case of the once through cycle for light water reactors.

08/02557 Hafnium clad fuels for fast spectrum BWRs

Wallenius, J. and Westlén, D. *Annals of Nuclear Energy*, 2008, 35, (1), 60–67.

In this paper, it is shown that by use of hafnium cladding, a fast neutron spectrum is achievable in the top of uprated BWRs. Monte Carlo calculations have been made for Hf clad inert matrix nitride and low fertile MOX fuels, with fuel segments located in the upper part of an uprated BWR, where the coolant void fraction exceeds 70%. The nitride fuel results in the hardest neutron spectrum, but the low fertile MOX fuel still yields fission probabilities for even neutron number nuclides similar to those of sodium cooled reactors. The inert matrix nitride fuel configuration yields high burning rates, permitting to stabilise TRU inventories with less than 50% BWR cores of the here suggested type in the power park. The core with low fertile MOX fuel is less efficient, but still a zero net producer of TRU. Fuel and coolant temperature feedbacks are affected by introduction of absorbing elements in the fuel, but remain within acceptable ranges for the low fertile MOX fuel. Although control rod worths are reduced, shutdown margins are sufficient to ensure sub-criticality in cold conditions. From a materials point of view, the behaviour of hafnium-clad MOX fuel would be similar to zircalloy clad MOX fuel already used extensively in nuclear industry. Thus, if dynamic stability of the core can be ensured, the here proposed fuel may be considered as a low-cost solution for transmutation of minor actinides on industrial scale.

08/02558 Investigation of the properties of the nuclei used on the new generation reactor technology systems

Tel, E. *et al. Annals of Nuclear Energy*, 2008, 35, (2), 220–227.

The main application fields of the fast neutrons are accelerator-driven subcritical systems (ADS) and fusion–fission (hybrid) reactor systems for fission energy production. Thorium (Th) and uranium (U) are nuclear fuels in these reactor systems. Lead (Pb), bismuth (Bi) and tungsten (W) are the target nuclei in the ADS reactor systems. The technical design of ADS and hybrid reactor systems require much effort and data. The Hartree–Fock (H–F) method with an effective interaction with Skyrme forces is widely used for studying the properties of nuclei such as binding energy, root mean square (RMS) charge radii, mass radii, neutron density, proton density, electromagnetic multipole moments, etc. In this study, by using H–F method with interaction Skyrme RMS charge radii, RMS mass radii, neutron density and proton density were calculated for the ^{232}Th, ^{238}U, ^{207}Pb, ^{209}Bi and ^{184}W isotopes. The calculation results of charge radii were compared with experimental data. Obtained RMS mass radii, neutron density and proton density results were discussed for ADS and hybrid reactor systems.

08/02559 One-dimensional experiments of a natural circulation two-phase flow under an external reactor vessel cooling

Kim, J. C. *et al. International Communications in Heat and Mass*, 2008, 35, (6), 716–722.

During a severe accident in a nuclear power plant, a decay heat from a molten corium should be removed to maintain an integrity of the reactor vessel. This feasible strategy can be achieved by a external reactor vessel cooling (ERVC) which requires a coolant to be circulated sufficiently between the reactor vessel and its insulation. For this reason, one-dimensional experiments were conducted to estimate the natural circulation flow under the ERVC condition of the APR1400. The experimental facility is one-dimensional and scaled down to be a half height and a 1/238 channel area of the APR1400 reactor vessel. The natural circulation mass flow rates were measured with the various coolant inlet/outlet areas, heights of the supplied water level and the coolant outlet, and steam generation rates. In results, the natural circulation mass flow rates mainly depended on the inlet/outlet area, and the natural circulation mass flow rate increased, as the outlet height as well as the supplied water level increased.

08/02560 Overview of the tritium system of Ignitor

Rizzello, C. and Tosti, S. *Fusion Engineering and Design*, 2008, 83, (4), 594–600.

Among the recent design activities of the Ignitor program, the analysis of the tritium system has been carried out with the aim to describe the main equipments and the operations needed for supplying the deuterium–tritium mixtures and recovering the plasma exhaust. In fact, the tritium system of Ignitor provides for injecting deuterium–tritium mixtures into the vacuum chamber in order to sustain the fusion reaction: furthermore, it generally manages and controls the tritium and the tritiated materials of the machine fuel cycle. Main functions consist of tritium storage and delivery, tritium injection, tritium recovery from plasma exhaust, treatment of the tritiated wastes, detritiation of the contaminated atmospheres, tritium analysis and accountability. In this work an analysis of the designed tritium system of Ignitor is summarized.

08/02561 Predicting local distributions of erosion–corrosion wear sites for the piping in the nuclear power plant using CFD models

Ferng, Y. M. *Annals of Nuclear Energy*, 2008, 35, (2), 304–313.

The erosion–corrosion (E/C) wear is an essential degradation mechanism for the piping in the nuclear power plant, which results in the oxide mass loss from the inside of piping, the wall thinning, and even the pipe break. The pipe break induced by the E/C wear may cause costly plant repairs and personal injuries. The measurement of pipe wall thickness is a useful tool for the power plant to prevent this incident. In this paper, CFD models are proposed to predict the local distributions of E/C wear sites, which include both the two-phase hydrodynamic model and the E/C models. The impacts of centrifugal and gravitational forces on the liquid droplet behaviours within the piping can be reasonably captured by the two-phase model. Coupled with these calculated flow characteristics, the E/C models can predicted the wear site distributions that show satisfactory agreement with the plant measurements. Therefore, the models proposed herein can assist in the pipe wall monitoring program for the nuclear power plant by way of concentrating the measuring point on the possible sites of severe E/C wear for the piping and reducing the measurement labour works.

08/02562 Progress in lattice Boltzmann methods for magnetohydrodynamic flows relevant to fusion applications

Pattison, M. J. *et al. Fusion Engineering and Design*, 2008, 83, (4), 557–572.

In this paper, an approach to simulating magnetohydrodynamic (MHD) flows based on the lattice Boltzmann method (LBM) is presented. The dynamics of the flow are simulated using a so-called multiple relaxation time (MRT) lattice Boltzmann equation, in which a source term is included for the Lorentz force. The evolution of the magnetic induction is represented by introducing a vector distribution function and then solving an appropriate lattice kinetic equation for this function. The solution of both distribution functions are obtained through a simple, explicit, and computationally efficient stream-and-collide procedure. The use of the MRT collision term enhances the numerical stability over that of a single relaxation time approach. To apply the methodology to solving practical problems, a new extrapolation-based method for imposing magnetic boundary conditions is introduced and a technique for simulating steady-state flows with low magnetic Prandtl number is developed. In order to resolve thin layers near the walls arising in the presence of high magnetic fields, a non-uniform gridding strategy is introduced through an interpolated-streaming step applied to both distribution functions. These advances are particularly important for applications in fusion engineering where liquid metal flows with low magnetic Prandtl numbers and high Hartmann numbers are introduced. A number of MHD benchmark problems, under various physical and geometrical conditions are presented, including three-dimensional MHD lid driven cavity flow, high Hartmann number flows and turbulent MHD flows, with good agreement with prior data. Due to the local nature of the method, the LBM also demonstrated excellent performance on parallel machines, with almost linear scaling up to 128 processors for a MHD flow problem.

08/02563 Properties of noble gases and binary mixtures for closed Brayton cycle applications

Tournier, J.-M. P. and El-Genk, M. S. *Energy Conversion and Management*, 2008, 49, (3), 469–492.

A review is conducted of the properties of the noble gases, helium, neon, argon, krypton and xenon, and their binary mixtures at pressures from 0.1 to 20 MPa and temperatures up to 1400 K. An extensive database of experimental measurements is compiled and used to develop semi-empirical properties correlations. The correlations accurately account for the effects of pressure and temperature on the thermodynamic and transport properties of these gases for potential uses in space ($\sim$2 MPa and up to 1400 K) and terrestrial ($\sim$7.0 MPa and up to 1200 K) applications of closed Brayton cycle (CBC). The developed correlations are based on the Chapman–Enskog kinetic theory for dilute gases, and on the application of the law of corresponding states to account for the dependence of properties on pressure. The correlations use the critical temperature and density of the gases as scaling parameters, and their predictions are compared with the compiled database. At temperatures $\geq$400 K and pressures $\leq$2 MPa in CBC space power systems, He and Ne, and the binary mixtures of He–Xe and He–Kr with molecular weights $\leq$40 g/mole behave essentially like a perfect gas, and the error of neglecting the effect of pressure on their compressibility factor, specific heats and transport properties is $\leq$1%. At a typical operating pressure of 7.0 MPa and up to 1200 K in terrestrial CBC power plants, neglecting the effect of pressure can result in $\sim$4% error in the properties of noble gases and the binary mixtures of He–Xe and He–Kr with molecular weights $\leq$40 g/mole, and as much as 20% error for pure argon. Therefore, when operating at pressures $<$2.0 MPa and/or using noble gases or binary mixtures with molecular weights $>$40 g/mole, the present correlations should be used to accurately predict the thermodynamic and transport properties.

08/02564 Review of recent advances of radioisotope power systems

Lange, R. G. and Carroll, W. P. *Energy Conversion and Management*, 2008, 49, (3), 393–401.

Radioisotope power systems have demonstrated numerous advantages over other types of power supplies for long-lived, unattended applications in space and in remote terrestrial locations. Many especially challenging power applications can be satisfied by proper selection, design, and integration of the radioisotope heat source and the power conversion technologies that are now available or that can be developed. This paper provides a brief review of the factors influencing selection of radioisotopes and design of power systems, and discusses the current state of practice and future programmatic and technical challenges to continued use of radioisotope power systems in space.

08/02565 Review of the studies on fundamental issues in LBE corrosion

Zhang, J. and Li, N. *Journal of Nuclear Materials*, 2008, 373, (1–3), 351–377.

Lead bismuth eutectic (LBE) technology is being developed for applications in advanced nuclear systems and high-power spallation neutron targets. In this paper, the current understanding of corrosion and the fundamental issues relevant to corrosion when using LBE as a heavy liquid metal nuclear coolant are reviewed. Corrosion mechanisms and processes in LBE are examined. Prospective methods to mitigate corrosion are briefly surveyed. Then, the oxygen control technique for corrosion mitigation was discussed in detail, including the range of oxygen concentrations in LBE, oxygen sensors, and the surface oxidation kinetics. Existing experimental results are summarized and reviewed. Theoretical corrosion models for non-isothermal liquid metal loops are refined and compared each other. The applications of these models to a few practical lead-alloy systems are used to illustrate the corrosion mechanisms and the parameter dependency, and to benchmark. Based on the current state of knowledge, a number of research and development tasks are proposed to fill the gaps and firmly establish the scientific underpinning before LBE nuclear coolant technology is ready for programmatic and industrial applications.

08/02566 SCALE analysis of CLAB decay heat measurements for LWR spent fuel assemblies

Ilas, G. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 37–48.

A set of decay heat measurements for spent fuel assemblies recently carried out at the Swedish central interim storage facility for spent fuel, CLAB, was analysed with the SCALE code system. The measurements include a variety of light water reactor assemblies that cover a large burnup range – up to 51 GWd/MTU – and a cooling time domain of interest to spent fuel storage and transportation applications. The results of the analysis show a good agreement between measured and predicted decay heat, with the calculated decay heat in general within the range of the uncertainty of the measured value. The effect of various assembly data on the calculated decay heat is analysed and discussed. Uncertainties that may arise from various approaches and assumptions in the computational model are identified and examined.

08/02567 Simulation on the start-up of MED seawater desalination system coupled with nuclear heating reactor

Ge, Z. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 203–210.

The mathematical control model for dynamic start-up process of the VTE-MED seawater desalination system was established employing the previous developed non-linear differential equations for system design and performance analysis. The influences on the start-up process of the operating parameters, such as the initial feed brine flow rate and the top brine temperature were analysed. The relationships among the feed brine flow rate, the gained output ratio and the start-up time were also investigated, which can be evidence to determine the optimal initial feed brine flow rate. The results also indicate that the system can consume the total heat rating generated by the low temperature nuclear heating reactor (LT-NHR) even at the most initial start-up stage, implying the present desalination system has excellent coupling characteristics with the LT-NHR. With necessary experiments verifications, the start-up control model developed in this paper can be the theoretical base for the analysis of dynamic performances of the seawater desalination system.

08/02568 The microstructure of nuclear graphite binders

Wen, K. Y. *et al. Carbon*, 2008, 46, (1), 62–71.

The microstructures of the binder in two grades of nuclear graphite, Gilsocarbon graphite and Pile Grade A graphite, were characterized by light microscopy, transmission electron microscopy and high resolution transmission electron microscopy. A variety of structures of carbon were observed, including a well-graphitized structure, nanosized graphite particles, quinoline insoluble (QI) particles, chaotic structures and non-graphitizing carbon. QI particles were observed on the surface of mesophase spheres as well as inside mesophase spheres. The aggregation of QI particles on the surface of mesophase spheres, or very near the surface in mesophase spheres, appears to have a significant influence on the development of the mesophase structure, resulting in refinement of the mesophase spheres before their coalescence. The chaotic structure, which is turbostratic and isotropic, is suggested to have developed from the isotropic pitch remaining between mesophase spheres. The non-graphitizing carbon consisted of flat and curved single layer graphene fragments with a size typically less than 1 nm. The formation of the various structures in the two graphites is attributed to the introduction of different pitches at stages of the graphite manufacture.

08/02569 Tritium diffusivity in crystal grain of Li_2TiO_3 and tritium release behavior under several purge gas conditions

Kinjyo, T. *et al. Fusion Engineering and Design*, 2008, 83, (4), 580–587.

It has been reported by the present authors that behaviour of tritium release from solid breeder grain is consisted of diffusion in grain, tritium transfer at surface layer and surface reactions on grain surface such as adsorption or isotope exchange reactions. Tritium release curves estimated using the tritium release model gave good agreement with observed tritium release curves from Li_4SiO_4, Li_2ZrO_3 or $LiAlO_2$. Tritium release behaviour from Li_2TiO_3 under humid purge gas, dry purge gas and dry purge gas with hydrogen conditions is discussed in this study, tritium release curves using the release model that the authors proposed previously give a good agreements with experimental tritium release curves. Tritium effective diffusivity in the crystal grain of Li_2TiO_3 is also estimated in this study using a curve-fitting method applied to the release curves obtained under the humid purge gas condition. It is discussed that change of colour of Li_2TiO_3 surface under hydrogen purge gas condition is observed and this phenomenon might affect tritium release behaviour from Li_2TiO_3.

Economics, policy, supplies, forecasts

08/02570 A web-based integrated data processing system for the TRIAM-1M

Hasegawa, M. *et al. Fusion Engineering and Design*, 2008, 83, (4), 588–593.

In TRIAM-1M, plasma discharge can be sustained for over 5 hours. In order to avoid sitting in front of one console for the purpose of monitoring the plasma discharge, it is recommended that the experimental information be accessible from any location at any time. In addition, simple services to access experimental information are required in order to promote the participation of multiple researchers in the TRIAM-1M experiment. Thus, A web-based integrated data processing system that provides management for experiment planning, an experimental log, numerical data, and plasma supervision has been installed in the TRIAM-1M. These services are composed primarily of an Apache web server, a Tomcat JSP/Servlet container, and a MySQL relational database. This system is constructed using the object-oriented Java language, which is easy to maintain and develop because of the intrinsic characteristics of the Java language. When participating in experiments, researchers are required only to prepare a web browser on any platform and are no longer required to memorize complex operations because all services are provided with a uniform user interface through a web browser. Furthermore, with the integration of these services, the required information and numerical data can be provided promptly by tracing HTML links that are created dynamically by server applications.

08/02571 Adsorption capacity of hydrogen isotopes on mordenite

Kawamura, Y. *et al. Fusion Engineering and Design*, 2008, 83, (4), 655–660.

In a fusion reactor system, a monitoring of hydrogen isotopes including tritium is necessary for the safety of system control and operation. A gas chromatography using a cryogenic separation column is one of the methods for hydrogen isotope analysis. Synthesis zeolite such as molecular sieve 5A (CaA) is a candidate material of the separation column, and its property varies by the ratio of silica to alumina, the kinds of cation and so on. If the factor affected the hydrogen adsorption property of the synthesis zeolite is clarified, it may lead to the development of the new zeolite optimized to the separation column. So, in this work, adsorption capacity of hydrogen (H_2) and deuterium (D_2) for mordenite (MOR) and NaY type zeolite (NaY) were investigated at various temperatures, and were compared with CaA. The amount of adsorption per unit weight of MOR was larger than that of CaA, and that of NaY was smaller than that of CaA. The adsorption isotherms were expressed by sum of two Langmuir equations, and the Langmuir coefficients of H_2 and D_2 were proposed. Furthermore, the Langmuir coefficients of HD, HT, DT and T_2 were estimated by the reduced mass. The correlation between the adsorption properties and the physical parameters of the zeolite were not confirmed.

08/02572 An international comparison of regulatory organizations and licensing procedures for new nuclear power plants

Bredimas, A. and Nuttall, W. J. *Energy Policy*, 2008, 36, (4), 1344–1354.

This paper considers measures needed to license new nuclear power plants efficiently. The analysis is based on international standards and a comparison of the national regulatory and licensing framework in seven countries (Canada, France, Germany, Japan, Switzerland, the UK and the USA). The review is split into the organization of regulatory responsibilities and the licensing process. A set of considerations is proposed that should be incorporated into national solutions. While conscious of the different cultural fundamentals of each region, it is hoped this paper will help fuel an emerging debate on this highly topical issue.

08/02573 Design and thermal modeling of radially configured nuclear waste packages

Kar, P. *et al. Annals of Nuclear Energy*, 2008, 35, (2), 246–262.

A series of radial design configurations for packaging nuclear wastes are described. These radial arrangements for used nuclear fuel assemblies in containers are effective techniques for packaging significantly more radioactive waste in the available internal container volume. The radial package designs can be applied to packaging the nuclear waste for permanent storage at the Yucca Mountain repository. The radially configured containers will have high degree of structural strength and will be efficient in transferring heat from the waste form to the package surface due to the minimization of internal gaps. Radial configurations are reported for packaging the boiling water reactor and pressurized water reactor used fuel assemblies. These configurations can be varied for co-packaging the colder, i.e. vitrified high level waste, canisters. Details of the geometry and the materials selected are discussed. Thermal analysis of the radial designs was conducted which confirm the feasibility of the designs demonstrating that no over-heating occurs in the contained nuclear waste in spite of the significantly extra amount of waste. The larger amount of packaged waste per container coupled with efficient heat transfer characteristics of these designs favour hotter and drier conditions for container surfaces in the Yucca Mountain emplacement drifts.

08/02574 Development of the supervisory discharge operation monitoring system for JT-60

Sueoka, M. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 283–286.

For safety and efficient operation of a fusion device, appropriate information should be provided to the personnel participating in the experiment. In a continuing effort to meet this requirement, the authors recently developed highlight displays showing the plasma movie, the status of the discharge sequence, the discharge schedule, the status of present troubles, etc. These highlight displays are presented on the large (65 in.) television monitor in front of the central consoles. These displays are automatically changed according to the timing signals of the JT-60 discharge sequence and/or at the JT-60 session leader's request. This system is called 'the supervisory discharge operation monitoring system'. This report describes the technical details of both this system and the discharge information management system (DIMS).

08/02575 Geochemical modelling of the weathering zone of the 'Mina Fe' U deposit (Spain): a natural analogue for nuclear spent fuel alteration and stability processes in radwaste disposal

Arcos, D. *et al. Applied Geochemistry*, 2008, 23, (4), 807–821.

The 'Mina Fe' U deposit (Salamanca, Spain) has been studied in the context of Enresa's programme for U-mine sites restoration and also as a natural analogue for processes in high-level nuclear waste (HLNW) geological disposal. The investigations encompassed an array of geoscience disciplines, such as structural geology, mineralogy, hydrogeology and elemental and isotopic geochemistry and hydrogeochemistry of the site. Based on the obtained results, a conceptual mineralogical and geochemical model was performed integrating the main geochemical processes occurring at the site: the interaction between oxidized and slightly acidic water with pyrite, pitchblende, calcite and dolomite, as essential minerals of the U fracture-filling mineralisation, and hydroxyapatite from the host rock, as the main source of P. This conceptual model has been tested in a systematic numerical model, which includes the main kinetic (pyrite and pitchblende dissolution) and equilibrium processes (carbonate mineral dissolution, and goethite, schoepite and autunite secondary precipitation). The results obtained from the reactive-transport model satisfactorily agree with the conceptual model previously established. The assumption of the precipitation of coffinite as a secondary mineral in the system cannot be correctly evaluated due to the lack of hydrochemical data from the reducing zone of the site and valid thermodynamic and kinetic data for this hydrated U(IV)-silicate. This precipitation can also be hampered by the probable existence of dissolved U(IV)-organic matter and/or uranyl carbonate complexes, which are thermodynamically stable under the alkaline and reducing conditions that prevail in the reducing zone of the system. Finally, the intense downwards oxic and acidic alteration in the upper part of the system is of no relevance for the performance assessment of a HLNW disposal. However, the acidic and oxidized conditions are quickly buffered to neutral–alkaline and reducing at very shallow depths, of relevance for the performance assessment of a HLNW repository, even in a natural or artificially perturbed geological environment as 'Mina Fe'.

08/02576 Nuclear energy in China: contested regime

Xu, Y. *Energy*, 2008, 33, (8), 1197–1205.

China is leading the recent revival of nuclear energy programs; it is building not one but four nuclear power plants at a time. The government is determined to expand nuclear energy programs and the general public supports the efforts. China also has the financial and human resources to achieve the desired objective – building 40 GW generation capacity by 2020. The politics surrounding nuclear energy expansion, however, is fluid and competition for influence is vibrant. Nuclear energy issues have become openly contested between general economic and specific industry interests and between international and domestic perspectives and designs. This article examines the political dynamics in China to show how the rival players and their competing interests shape the strategy of nuclear energy development.

08/02577 Recent advances in nuclear powered electric propulsion for space exploration

Cassady, R. J. *et al. Energy Conversion and Management*, 2008, 49, (3), 412–435.

Nuclear and radioisotope powered electric thrusters are being developed as primary in space propulsion systems for potential future robotic and piloted space missions. Possible applications for high-power nuclear electric propulsion include orbit raising and maneuvering of large space platforms, lunar and Mars cargo transport, asteroid rendezvous and sample return, and robotic and piloted planetary missions, while lower power radioisotope electric propulsion could significantly enhance or enable some future robotic deep space science missions. This paper provides an overview of recent US high-power electric thruster research programs, describing the operating principles, challenges, and status of each technology. Mission analysis is presented that compares the benefits and performance of each thruster type for high priority NASA missions. The status of space nuclear power systems for high-power electric propulsion is presented. The paper concludes with a discussion of power and thruster development strategies for future radioisotope electric propulsion systems.

08/02578 Sharing product data of nuclear power plants across their lifecycles by utilizing a neutral model

Mun, D. *et al. Annals of Nuclear Energy*, 2008, 35, (2), 175–186.

Many public and private Korean organizations are involved during the lifecycle of a domestic nuclear power plant. Korea Plant Engineering Co. (KOPEC) participates in the design stage, Korea Hydraulic and Nuclear Power (KHNP) operates and manages all nuclear power plants in Korea, Doosan Heavy Industry and Construction Co. manufactures the main equipment, and a construction company constructs the plant. Even though each organization has its own digital data management system and obtains a certain level of automation, data sharing among organizations is poor. KHNP obtains drawings and technical specifications from KOPEC in the form of paper. This results in manual rework of definitions, and errors can potentially occur in the process. In order to establish an information bridge between design and operation and maintenance (O&M) phases, a generic product model, a data model from Hitachi, is extended for constructing a neutral data warehouse and the Korean Nuclear Power Plant Information Sharing System is implemented.

08/02579 Space nuclear reactor power system concepts with static and dynamic energy conversion

El-Genk, M. S. *Energy Conversion and Management*, 2008, 49, (3), 402–411.

Nuclear reactor power systems could revolutionize space exploration and support human outpost on the Moon and Mars. This paper reviews current static and dynamic energy conversion technologies for use in space reactor power systems and provides estimates of the system's net efficiency and specific power, and the specific area of the radiator. The suitable combinations of the energy conversion technologies and the nuclear reactors, classified based on the coolant type and cooling method, for best system performance and highest specific power, are also discussed. In addition, four space reactor power system concepts with both static and dynamic energy conversion are presented. These systems concepts are for nominal electrical powers up to 110 kW_e and have no single point failures in reactor cooling, energy conversion and heat rejection. Two power systems employ liquid metal heat pipes cooled reactors, thermoelectric (TE) and alkali-metal thermal-to-electric conversion units for converting the reactor power to electricity, and potassium heat pipes radiators. The third power system employs SiGe TE converters and a liquid metal cooled reactor, with a core divided into six identical sectors. Each sector has a separate energy conversion loop, a heat rejection loop, and a rubidium heat pipes radiator panel. The fourth power system has a gas-cooled reactor, with a sectored core. Each of the three sectors in the core is coupled to a separate closed Brayton cycle loop with He–Xe (40 g/mol) working fluid and a NaK-78 secondary loop, and two separate water heat pipes radiator panels.

08/02580 The possible role of nuclear energy in Italy

Esposto, S. *Energy Policy*, 2008, 36, (5), 1584–1588.

Italy, after the vote of the referendum in 1987, stopped producing electricity from nuclear fuel for the energy demand. This paper analyses the current Italian energy outlook and clarifies how the choice to abandon the nuclear option damaged the economy. Nowadays, the possible reintroduction of civil nuclear option is hindered by groups claiming that nuclear energy is not convenient and is incredibly dangerous. In this paper it is clarified with international references how this is not correct and why Italy should start thinking seriously and without prejudices at future energy options.

08/02581 The role of nuclear energy in Lithuania under various post-Kyoto climate change mitigation regimes

Streimikiene, D. *Energy*, 2008, 33, (7), 1005–1014.

The article aims to evaluate the potential role of nuclear energy in Lithuania under various post-Kyoto climate change mitigation regimes. Seeking to achieve this target the analysis of possible energy sector development scenarios in Lithuania was performed and CO_2 emission projections for these scenarios were developed. The analysis of post-Kyoto climate change mitigation architectures was performed and the requirements of these possible climate change mitigation regimes for greenhouse gas (GHG) emission reduction in Lithuania were assessed. Based on these assessments the potential role of new nuclear power in Lithuania was identified under various future climate change mitigation regimes.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

08/02582 Design and performance evaluation of an innovative small scale combined cycle cogeneration system

Badami, M. *et al. Energy*, 2008, 33, (8), 1264–1276.

This paper deals with an innovative natural gas (NG) combined cycle cogeneration system (150-kW$_e$, 192 kW$_t$). The system is made up of a combination of two interconnected combined heat and power (CHP) systems: a reciprocating internal combustion engine (ICE) cogenerator as the topping cycle and a Rankine cycle (RC) cogenerator which operates as the bottoming cycle on the exhaust gases from the ICE. The expander technology chosen for the RC prime mover is a reciprocating single expansion steam engine with three cylinders in a radial architecture. The ICE is an automotive derived internal combustion engine with a high part-load electrical efficiency, due to a variable speed operation strategy and reduced emissions. The main design parameter of the Rankine bottoming cycle and of the steam engine are defined in this paper, and the electrical and heat efficiency of the new CHP unit are determined and discussed at full and part-load. Some design criteria and energy balance considerations are introduced and some technical solutions are analysed and studied.

08/02583 Dynamical prediction and pattern mapping in short-term load forecasting

Aguirre, L. A. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 73–82.

The authors' intention when writing their paper was not to put forward yet another scheme for short-term load forecasting but rather to provide evidence that may improve the understanding about fundamental issues which underly load forecasting problems. In particular, load forecasting will be decomposed into two main problems, namely dynamical prediction and pattern mapping. It is argued that whereas the latter is essentially static and becomes non-linear when weekly features in the data are taken into account, the former might not be deterministic at all. In such cases there is no determinism (serial correlations) in the data apart from the average cycle and the best a model can do is to perform pattern mapping. Moreover, when there is determinism in addition to the average cycle, the underlying dynamics are sometimes linear, in which case there is no need to resort to non-linear models to perform dynamical prediction. Such conclusions were confirmed using real load data and surrogate data analysis. In a sense, the paper details and organizes some general beliefs found in the literature on load forecasting. This sheds some light on real model-building and forecasting problems and helps understand some apparently conflicting results reported in the literature.

08/02584 Method for effects evaluation of some forms of power transformers preventive maintenance

Mijailovic, V. *Electric Power Systems Research*, 2008, 78, (5), 765–776.

The paper suggests a method for effects evaluation of a few activities and measures, undertaken as a part of preventive maintenance of power transformers. The method enables calculation of expected failures repair cost and load curtailment cost. The method identifies minor and major failures. Power transformer is a complex system, consisting of five components (functional parts). It is assumed that each component has two independent, competing failure modes: wear-out failure mode, modelled by two-parameter Weibull distribution, and a chance failure mode, characterized by an exponential distribution. The application of the method is demonstrated for one transformer station (TS) 110/*x* kV/kV with 2×31.5 MVA transformers. Also, by applying the method, influence of system for condition monitoring of transformer windings and oil on failures repair cost and load curtailment cost is evaluated.

08/02585 Neural network-based voltage regulator for an isolated asynchronous generator supplying three-phase four-wire loads

Singh, B. and Kasal, G. K. *Electric Power Systems Research*, 2008, 78, (6), 985–994.

This paper deals with a neural network-based solid state voltage controller for an isolated asynchronous generator driven by constant speed prime mover like diesel engine, bio-gas or gasoline engine and supplying three-phase four-wire loads. The proposed control scheme uses an indirect current control and a fast adaptive linear element (adaline) based neural network reference current extractor, which extracts the real positive sequence current component without any phase shift. The neutral current of the source is also compensated by using three single-phase bridge configuration of insulated gate bipolar junction transistor (IGBT) based voltage source converter (VSC) along-with single-phase transformer having self-supported dc bus. The proposed controller provides the functions as a voltage regulator, a harmonic eliminator, a neutral current compensator, and a load balancer. The proposed isolated electrical system with its controller is modelled and simulated in MATLAB along with Simulink and power system block set toolboxes. The simulated results are presented to demonstrate the capability of an isolated asynchronous generating system driven by a constant speed prime mover for feeding three-phase four-wire loads.

08/02586 Nonlinear state space model identification of synchronous generators

Dehghani, M. and Nikravesh, S. K. Y. *Electric Power Systems Research*, 2008, 78, (5), 926–940.

A method for identification of a synchronous generator is suggested in this paper. The method uses the theoretical relations of machine parameters and the Prony method to find the state space model of the system. Such models are useful for controller design and stability tests. The proposed identification method is applied to a third-order model of a synchronous generator. In this study, the field voltage is considered as the input and the active output power and the rotor angle are considered as the outputs of the synchronous generator. Simulation results show good accuracy of the identified model.

08/02587 Optimal conductor sizing in radial distribution systems planning

Kaur, D. and Sharma, S. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 261–271.

In this paper, a generalized model for optimal multiconductor size selection in planning of radial distribution system planning is presented. The model takes into account nonuniform loading, increase in load, load factor, cost of energy, cost of power, and diversity in load peaks at various load points along the feeder. The optimal conductor sizes are determined by minimizing the total cost consisting of cost of conductor and cost of losses and subject to the constraint on voltage drop at far end load points and maximum current carrying capacity of the feeder. An efficient method is presented to solve this problem in which the search space is enumerated systematically and efficiently. To reduce the search space, logical decisions are developed and only those feasible solutions are considered for functional evaluation, which are close to the boundary of the constraints. The method developed is applicable to straight as well as branched radial feeders. The effectiveness and applicability of the proposed approach is illustrated with suitable examples.

08/02588 Short-term operation planning on cogeneration systems: a survey

Salgado, F. and Pedrero, P. *Electric Power Systems Research*, 2008, 78, (5), 835–848.

This paper presents a survey of the developed researches from 1983 up to 2006 related to the cogeneration systems. The survey is focused on short-term operation planning and papers are grouped according to the most important characteristics. This paper contributes to: (i) give an extensive survey in the area and (ii) mention aspects in the short-term operation planning that have been poorly developed and where future contributions are required.

08/02589 Transmission loss allocation based on optimal power flow and sensitivity analysis

Belati, E. A. and da Costa, G. R. M. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 291–295.

This paper presents a new approach to the transmission loss allocation problem in a deregulated system. This approach belongs to the set of incremental methods and treats all the constraints of the network, i.e. control, state and functional constraints. The approach is based on the perturbation of optimum theorem. From a given optimal operating point obtained by the optimal power flow the loads are perturbed and a new optimal operating point that satisfies the constraints is determined by the sensibility analysis. This solution is used to obtain the allocation coefficients of the losses for the generators and loads of the network. Numerical results show the proposed approach in comparison to other methods obtained with well-known transmission networks, IEEE 14-bus. Other test emphasizes the importance of considering the operational constraints of the network. And finally the approach is applied to an actual Brazilian equivalent network composed of 787 buses, and it is compared with the technique used at the present time by the Brazilian Control Centre.

Economics, policy, supplies, forecasts

08/02590 A critical review of reductionist approaches for assessing the progress towards sustainability

Gasparatos, A. *et al. Environmental Impact Assessment Review*, 2008, 28, (4–5), 286–311.

The increasing prominence of Sustainable Development as a policy objective has initiated a debate on appropriate frameworks and tools that will both provide guidance for a shift towards sustainability as well as a measure, preferably quantitative, of that shift. Sustainability assessment has thus the challenging task of capturing, addressing and suggesting solutions for a diverse set of issues that affect stakeholders with different values and span over different spatial and temporal scales. However sustainability assessment is still not a mature framework in the sense that environmental impact assessment and strategic environmental assessment are. This paper aims to provide suggestions for improving the sustainability evaluation part of a sustainability assessment. In particular it will provide a comprehensive review of different sustainability evaluation tools (from a reductionist perspective) as well as the feasibility of incorporating them within a sustainability assessment framework. Reviewed tools include monetary tools, biophysical models and sustainability indicators/composite indices that have been developed within different disciplines such as economics, statistics, ecology, engineering and town planning.

08/02591 A new optimization model for distribution substation siting, sizing, and timing

El-Fouly, T. H. M. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (5), 308–315.

This paper presents a new planning optimization model for distribution substation siting, sizing, and timing. The proposed model involves using linear functions to express the total cost function. The developed model includes different electrical constraints such as voltage drops, substation and transformer capacities, power flow, and radial flow constraints. The proposed planning problem is formulated as a mixed integer linear programming (MILP) problem to avoid the use of non-linear programming and thus avoiding the possibility of getting trapped in local solutions. A numerical example is presented to validate the effectiveness of the developed model.

08/02592 Agent-based power sharing scheme for active hybrid power sources

Jiang, Z. *et al. Journal of Power Sources*, 2008, 177, (1), 231–238.

The active hybridization technique provides an effective approach to combining the best properties of a heterogeneous set of power sources to achieve higher energy density, power density and fuel efficiency. Active hybrid power sources can be used to power hybrid electric vehicles with selected combinations of internal combustion engines, fuel cells, batteries, and/or supercapacitors. They can be deployed in all-electric ships to build a distributed electric power system. They can also be used in a bulk power system to construct an autonomous distributed energy system. An important aspect in designing an active hybrid power source is to find a suitable control strategy that can manage the active power sharing and take advantage of the inherent scalability and robustness benefits of the hybrid system. This paper presents an agent-based power sharing scheme for active hybrid power sources. To demonstrate the effectiveness of the proposed agent-based power sharing scheme, simulation studies are performed for a hybrid power source that can be used in a solar car as the main propulsion power module. Simulation results clearly indicate that the agent-based control framework is effective to coordinate the various energy sources and manage the power/voltage profiles.

08/02593 An evaluation of the environmental burdens of present and alternative materials used for electricity transmission

Blackett, G. *et al. Building and Environment*, 2008, 43, (7), 1326–1338.

This paper describes research using life cycle analysis assessment techniques to determine the environmental impacts associated with the use of present and possible alternative materials utilised in all aspects of high voltage electricity transmission. The study focuses on the National Grid system in England and Wales, where the majority of high voltage electricity is transmitted through steel and aluminium conductors supported above the ground by mild steel lattice type towers. A major aspect of the study is to address the effects of different corrosive environments to which the tower materials are exposed: namely rural, industrial and coastal locations.

08/02594 Application of multiple tabu search algorithm to solve dynamic economic dispatch considering generator constraints

Pothiya, S. *et al. Energy Conversion and Management*, 2008, 49, (4), 506–516.

This paper presents a new optimization technique based on a multiple tabu search (MTS) algorithm to solve the dynamic economic dispatch (ED) problem with generator constraints. In the constrained dynamic ED problem, the load demand and spinning reserve capacity as well as some practical operation constraints of generators, such as ramp rate limits and prohibited operating zone are taken into consideration. The MTS algorithm introduces additional mechanisms such as initialization, adaptive searches, multiple searches, crossover and restarting process. To show its efficiency, the MTS algorithm is applied to solve constrained dynamic ED problems of power systems with 6 and 15 units. The results obtained from the MTS algorithm are compared to those achieved from the conventional approaches, such as simulated annealing, genetic algorithm, tabu search algorithm and particle swarm optimization. The experimental results show that the proposed MTS algorithm approaches is able to obtain higher quality solutions efficiently and with less computational time than the conventional approaches.

08/02595 Assessing knowledge-based resources in a utility company: identify and prioritise the balancing factors

Kayakutlu, G. and Büyüközkan, C. *Energy*, 2008, 33, (7), 1027–1037.

Confidence in the future of an enterprise success is only possible by balancing the resources and the expectations. The increase in knowledge-based resources request new assessment models. This study aims to demonstrate the divergence in value of the knowledge resources for different role players. Thus, knowledge management strategies can be reviewed as to support the future of the company. The case study is performed in a Turkish utility company, where, the role players have comparable influences on the future of the business. An integrated Delphi and fuzzy analytic hierarchy process based framework is used in analysis which also helps prioritizing the balancing factors according to the different role players. Achievements in the case study led for a mind-shift of considering the accordance of the sustainability and the resource balancing goals for the utility sector.

08/02596 Asynchronous decentralized method for interconnected electricity markets

Huang, A. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 283–290.

This paper presents an asynchronous decentralized method to solve the optimization problem of interconnected electricity markets. The proposed method decomposes the optimization problem of combined electricity markets into individual optimization problems. The impact of neighbouring markets' information is included in the objective function of the individual market optimization problem by the standard Lagrangian relaxation method. Most decentralized optimization methods use synchronous models of communication to exchange updated market information among markets during the iterative process. In this paper, however, the solutions of the individual optimization problems are coordinated through an asynchronous communication model until they converge to the global optimal solution of combined markets. Numerical examples are presented to demonstrate the advantages of the proposed asynchronous method over the existing synchronous methods.

08/02597 Competition policy and regulation in hydro-dominated electricity markets

Rangel, L. F. *Energy Policy*, 2008, 36, (4), 1292–1302.

This paper discusses the main competition issues that arise in electricity systems dominated by hydro generation, arguing that technological differences between hydro and thermal plants may allow hydropower producers to exert market power in different and subtler ways compared to thermal generators. The key for market power in hydro-based systems is the strategic allocation of a given amount of output across periods, rather than a straightforward reduction of total output. The paper examines the interaction between strategic hydro reservoir operation and transmission capacity constraints, and summarizes the implications of market power for system reliability. A review of recent relevant literature is included. Finally, possible interventions to mitigate market power are analysed.

08/02598 Contemporary issues in thermal gasification of biomass and its application to electricity and fuel production

Wang, L. *et al. Biomass and Bioenergy*, 2008, 32, (7), 573–581.

Gasification technology has been investigated to effectively and economically convert low-value and highly distributed solid biomass to a uniform gaseous mixture mainly including hydrogen (H_2), carbon monoxide (CO), methane (CH_4) and carbon dioxide (CO_2). This gaseous mixture can be further used as an industrial feedstock for heat and power generation, H_2 production and synthesis of liquid fuels. Significant advances have been made in the technology of biomass gasification and syngas utilization. This review was conducted to introduce the recent advances in biomass gasification and syngas utilization. The critical technical issues and perspectives of biomass gasification were discussed.

08/02599 Design of an economically efficient feed-in tariff structure for renewable energy development

Lesser, J. A. and Su, X. *Energy Policy*, 2008, 36, (3), 981–990.

Evidence suggests, albeit tentatively, that feed-in tariffs (FITs) are more effective than alternative support schemes in promoting renewable energy technologies (RETs). FITs provide long-term financial stability for investors in RETs, which, at the prevailing market price of electricity, are not currently cost-efficient enough to compete with traditional fossil fuel technologies. On the other hand, if not properly designed, FITs can be economically inefficient, as is widely regarded to have been the case under the Public Utility Regulatory Policies Act of 1978 (PURPA). Under PURPA, too high a guaranteed price led to the creation of so-called 'PURPA machines' – poorly performing generating units that could survive financially only because of heavy subsidies that came at the expense of retail customers. Similarly, because of their adverse impacts on retail electricity rates, German FITs have been subject to increasing political pressure from utilities and customers. The authors propose an innovative two-part FIT, consisting of both a capacity payment and a market-based energy payment, which can be used to meet the renewables policy goals of regulators. The two-part tariff design draws on the strengths of traditional FITs, relies on market mechanisms, is easy to implement, and also avoids the problems caused by distorting wholesale energy markets through above-market energy payments. The approach is modelled on forward capacity market designs that have been recently implemented by several regional transmission organizations in the USA in order to address needs for new generating capacity to ensure system reliability.

08/02600 Distribution network tariffs: a closed question?

Ortega, M. P. R. *et al. Energy Policy*, 2008, 36, (5), 1712–1725.

Electricity regulators are facing new challenges to keep the pace of the liberalization process and the revision of regulatory schemes that is taking place all over the world. The pressure is also felt by regulated activities such as distribution. One of the main objectives of this process is to improve efficiency. Electricity rates and more specifically distribution network tariffs should also be adapted to these new requirements. This paper describes the main rate design approaches that are used to recover distribution costs. Drawbacks of the current methods are highlighted, and a new tariff design methodology based on cost causality is presented. Efficiency achievement as well as compliance with legal and regulatory criteria, such as cost recovery and non-discrimination, is analysed.

08/02601 Do liberalised electricity markets help or hinder CHP and district heating? The case of the UK

Toke, D. and Fragaki, A. *Energy Policy*, 2008, 36, (4), 1448–1456.

This paper investigates whether and how Danish-style combined heat and power (CHP) and district heating (DH) can be implemented in the UK in the context of a liberalized electricity market. There is currently an absence, in the UK, of the Danish system of planning rules and also good tariffs for CHP electricity exports to the grid that have resulted in the development of the Danish system of CHP and DH. However, there are some changes in UK planning practice that may help CHP and DH. These areas would need to be strengthened, but it is also the case that the way the liberalized electricity market operates in the UK effectively discriminates against small CHP plant selling their electricity to the grid. A Danish system of 'aggregating' CHP–DH plant by using thermal stores could help to overcome this problem. However, an alternative strategy would be to establish feed-in tariffs for CHP units that are linked to DH modelled on the Danish 'triple tariff'. This could help the UK's long-term objective of absorbing high levels of fluctuating renewable energy sources.

08/02602 Dynamic intelligent cleaning model of dirty electric load data

Zhang, X. and Sun, C. *Energy Conversion and Management*, 2008, 49, (4), 564–569.

There are a number of dirty data in the load database derived from the supervisory control and data acquisition system. Thus, the data must be carefully and reasonably adjusted before it is used for electric load forecasting or power system analysis. This paper proposes a dynamic and intelligent data cleaning model based on data mining theory. Firstly, on the basis of fuzzy soft clustering, the Kohonen clustering network is improved to fulfill the parallel calculation of fuzzy c-means soft clustering. Then, the proposed dynamic algorithm can automatically find the new clustering center (the characteristic curve of the data) with the updated sample data; At last, it is composed with radial basis function neural network, and then, an intelligent adjusting model is proposed to identify the dirty data. The rapid and dynamic performance of the model makes it suitable for real time calculation, and the efficiency and accuracy of the model is proved by test results of electrical load data analysis in Chongqing.

08/02603 Estimating residential demand for electricity in the United States, 1965–2006

Dergiades, T. and Tsoulfidis, L. *Energy Economics*, 2008, 30, (5), 2722–2730.

This paper examines the residential demand for electricity in the US economy as a function of the per capita income, the price of electricity, the price of oil for heating purposes, the weather conditions and the stock of occupied housing over the period 1965–2006. This paper has two novelties: first, the occupied stock of houses as a proxy for the stock of electrical appliances and second the identification of a possible equilibrium relationship among the variables is ascertained through the recently advanced autoregressive distributed lag (ARDL) approach to cointegration. The empirical findings give support to a stable long-run relationship implying also short-run and long-run elasticities whose size and sign are comparable to other similar studies.

08/02604 From state monopoly to renewable portfolio: restructuring China's electric utility

Ma, C. and He, L. *Energy Policy*, 2008, 36, (5), 1697–1711.

Deregulation and decentralization in the electricity sector have thrived worldwide since the early 1980s. China also started restructuring its electricity industry since the mid-1980s. The reform shares many common features with restructuring practices in other countries and exhibits some unique characteristics as well. To some extent, two features, namely governmental administrative departments' dual role of government and business inherited from a highly centralized planned economy, and the coal-intensive nature of power generation, has determined many aspects of the evolution of China's electric power sector. This paper aims to provide a comprehensive account of the process with some emphasis on recent developments. Some of the features that are similar to electricity market reforms are also identified in other countries and, most importantly, those that characterize the uniqueness of the restructuring practices in China's electricity industry through investigating the administrative framework, price and investment mechanisms, and associated legislation and policy settings at each of the five stages in the evolution of the electric utility sector. The paper concludes with a discussion and summary of some generic characteristics and remaining challenges.

08/02605 Greenhouse gas emission reduction by means of fuel switching in electricity generation: addressing the potentials

Delarue, E. and D'haeseleer, W. *Energy Conversion and Management*, 2008, 49, (4), 843–853.

Many countries committed themselves in the Kyoto protocol to reduce greenhouse gas (GHG) emissions. Some of these targeted emission reductions could result from a switch from coal-fired to gas-fired electricity generation. The focus in this work lies on Western Europe, with the presence of the European Union Emission Trading Scheme (EU ETS). For the switching to occur, several conditions have to be fulfilled. First, an economical incentive must be present, i.e. a sufficiently high European Union Allowance (EUA) price together with a sufficiently low natural gas price. Second, the physical potential for switching must exist, i.e. at a given load, there must remain enough power plants not running to make switching possible. This paper investigates what possibilities exist for switching coal-fired plants for gas-fired plants, dependent on the load level (the latter condition above). A fixed allowance cost and a variable natural gas price are assumed. The method to address GHG emission reduction potentials is first illustrated in a methodological case. Next, the GHG emission reduction potentials are addressed for several western European countries together with a relative positioning of their electricity generation. GHG emission reduction potentials are also compared with simulation results. GHG emission reduction potentials tend to be significant. The Netherlands have a very widespread switching zone, so GHG emission reduction is practically independent of electricity generation. Other counties, like Germany, Spain and Italy could reduce GHG emissions significantly by switching. With an allowance cost following the switch level of a 50% efficient gas-fired plant and a 40% efficient coal-fired plant in the summer season (like in 2005), the global GHG emission reduction (in the electricity generating sector) for the eight modelled zones could amount to 19%.

08/02606 High performance direct ethanol fuel cell with double-layered anode catalyst layer

Wang, Q. *et al. Journal of Power Sources*, 2008, 177, (1), 142–147.

Double-layered anode catalyst layers with two reverse configurations, which consist of 45 wt.% Pt_3Sn/C and PtRu black catalyst layers, were fabricated to improve the performance of a direct ethanol fuel cell (DEFC). The in-house 45 wt.% Pt_3Sn/C catalyst was characterized by XRD and TEM. The cross-sectional double-layered anode catalyst layer was observed by SEM. In DEFC performance test and anode linear sweep voltammetry measurement, the anode with double-layered catalyst layer exhibited better catalytic activity for ethanol electro-oxidation than those with single-layered 45 wt.% Pt_3Sn/C and PtRu black catalyst layers. In terms of anode product distribution, the DEFC with double-layered anode catalyst layer showed a higher yield of acetic acid than that with single-layered PtRu black catalyst layer and a higher yield of CO_2 than that with single-layered 45 wt.% Pt_3Sn/C catalyst layer, respectively. These results suggest that the double-layered anode catalyst layer possessed the advantages of both Pt_3Sn/C and PtRu black catalysts for ethanol electro-oxidation, and thus showed a higher ethanol electro-oxidation efficiency and DEFC performance in the practical polarization potential region.

08/02607 Hybrid integer coded differential evolution – dynamic programming approach for economic load dispatch with multiple fuel options

Balamurugan, R. and Subramanian, S. *Energy Conversion and Management*, 2008, 49, (4), 608–614.

This paper presents a novel and efficient approach through a hybrid integer coded differential evolution – dynamic programming (IC-DEDP) scheme to solve the economic dispatch (ED) problem with multiple fuel options. A dynamic programming (DP) based simplified recursive algorithm is developed for optimal scheduling of the generating units in the ED problem. The proposed hybrid scheme is developed in such a way that an integer coded differential evolution (ICDE) is acting as a main optimizer to identify the optimal fuel options, and the DP is used to find the fitness of each agent in the population of the ICDE, which makes a quick decision to direct the search towards the optimal region. The hybrid ICDEDP decision vector consists of a sequence of integer numbers representing the fuel options of each unit to optimize quality of search and computation time. A gene swap operator is introduced in the proposed algorithm to improve its convergence characteristics. In order to show the efficiency and effectiveness, the proposed hybrid ICDEDP approach has been examined and tested with numerical results using the ten generation unit economic dispatch problem with multiple fuel options. The test result shows that the proposed hybrid ICDEDP algorithm has high quality solution, superior convergence characteristics and shorter computation time.

08/02608 Intra-day and regime-switching dynamics in electricity price formation

Karakatsani, N. V. and Bunn, D. W. *Energy Economics*, 2008, 30, (4), 1776–1797.

This paper analyses the complex, non-linear effects of spot price drivers in wholesale electricity markets: their intra-day dynamics and transient irregularities. The context is the UK market, after the reforms introduced in March 2001, analysed with an original set of price drivers reflecting economic, technical, strategic, risk, behavioural and market design effects. Models are estimated separately as daily time-series of the 48 half-hourly trading periods. All coefficients exhibit substantial intra-day variation, relating to the heterogeneity of operating plants and market design aspects. This reveals a market responding to economic fundamentals and plant operating properties, with learning and emergent financial characteristics, as well as some strategic manipulation of capacity, most effectively exercised by the more flexible plants. Using regime-switching parameters, the effects of capacity margin and inter-day capacity adjustment are elucidated, suggesting rent-seeking behaviour, despite the relatively low prices at the time. Overall, high-frequency, aggregate fundamental price models can usefully uncover critical aspects of market performance, evolution and agent behaviour.

08/02609 Load research as a tool in electric power system planning, operation, and control – the case of Jordan

Elkarmi, F. *Energy Policy*, 2008, 36, (5), 1757–1763.

Electric load research involves the systematic collection and analysis of customers' electrical energy as well as demand requirements by time-of-day, month, season, and year; consumption patterns; socio-economic and demographic influencing factors; and willingness-to-pay for electricity. The information created by load research are the bases for all studies and analyses conducted by the electricity company to plan, monitor, operate, and control the power system. Several attempts were carried out in Jordan to create this very important body of knowledge. Studies and analyses are conducted regularly to update the information. This paper presents the author's experience in conducting load research investigations. These efforts culminated in three distinct contributions, which are still very useful in planning and operation of the power system in Jordan. (1) The first contribution by the author is related to creating a huge database of energy and electricity consumption characteristics, trends, and driving forces. The database is being continuously updated and as such constitutes a very basic tool for all demand forecasting and other planning studies. (2) The second contribution involves the estimation of the cost of un-served (unmet) electrical energy due to outages. This estimate, which is still being used as reference for planning studies carried out in Jordan, was first coined by the author at 1.0US$/kWh. (3) The final contribution concerns the use of the information in the load research database and the accumulated experience in determining peak load composition. This effort created the 'near-exact' estimate of the characteristics and constitutions of the peak load divided among the various consuming sectors as well as among the various end-uses in Jordan. The results of these contributions are still being used by the electricity sector in Jordan until this day, either as unique information or as a guideline or reference to more recent estimates. More importantly, the efforts, as outlined in the three contributions above, have established a good base and reference point for further ongoing activities to collect, analyse, and use the information by various entities in the electricity sector in Jordan. However, the efforts need to be properly coordinated and entrusted with a single entity to ensure a better quality of information and avoid conflicting decisions.

08/02610 Market power in the European electricity market – the impacts of dry weather and additional transmission capacity

Lise, W. *et al*. *Energy Policy*, 2008, 36, (4), 1331–1343.

This paper uses a static computational game theoretic model of a fully open European electricity market and can take strategic interaction among electricity-producing firms into account. The model is run for a number of scenarios: first, in the baseline under perfect competition, the prices differ due to the presence of various generation technologies and a limited ability to exchange electricity among countries. In addition, when large firms exercise market power, the model runs indicate that prices are the highest in countries where the number of firms is low. Second, dry weather would increase the prices in the hydro-rich Nordic countries followed by the Alpine countries. The price response would be about 20% higher with market power. Third, more transmission capacity would lower the prices in countries with high prices and it also reduces the impact of market power. Hence, more transmission capacity can improve market competitiveness.

08/02611 Merging electricity and environment politics of Hong Kong: identifying the barriers from the ways that sustainability is defined

Lo, A. Y. X. *Energy Policy*, 2008, 36, (4), 1521–1537.

The present paper presents a study of the electricity policy of Hong Kong in an environmental–political context. Through a critical review of the policy structure and rationale, it identifies the barriers to developing a truly sustainable electricity policy system and is expected to shed light on the forthcoming electricity market reform in the territory. The barriers stem from the path-dependent institutional set-ups that restrict a timely transformation of the roles of the actors. And this is coupled with the government's treatment that does not look beyond these structural constraints, overly appreciating scientific and economic rationalities than communicative actions. The author is of the view that these are intensified by the sharp changes in the local political economy. Positive signs of change are dampened by the minimal progress in democratic development in the near future and the extension of the power companies' monopolist status that will ruin the 'trust' between the stakeholders compounding the guilt of those rigid regulatory constraints.

08/02612 Now that California has AMI, what can the state do with it?

Woo, C. K. *et al*. *Energy Policy*, 2008, 36, (4), 1366–1374.

Recognizing the lack of retail-demand response, a state regulator, such as the California Public Utilities Commission (CPUC), seeks tariff proposals that transmit wholesale price signals to a local distribution company's (LDC) retail customers. To enable these proposals, the CPUC has authorized funding for advanced metering infrastructure (AMI) for two investor-owned LDCs. Assuming regulatory approval of the third LDC's application, the state's US$4.28 billion AMI investment will aid new rate designs for 11.3 million electricity customers. Now that California has AMI, what can the state do with it? With AMI in hand, an LDC can implement service options that can further the state's energy initiatives, ranging from resource adequacy requirement (RAR) to greenhouse gas (GHG) emissions reduction. These options can efficiently allocate limited capacity based on each customer's willingness to pay, without the unnecessary distinction between price rationing and reliability differentiation. They can be Pareto superior, welfare dominating the default tariffs that apply to these customers. A case in point is the generalized demand subscription service (GDSS) option proposed in this paper. However, it is unclear whether the option will find wide customer acceptance, without an LDC's intensive customer education and marketing efforts.

08/02613 Optimal bidding strategies in oligopoly markets considering bilateral contracts and transmission constraints

Badri, A. *et al*. *Electric Power Systems Research*, 2008, 78, (6), 1089–1098.

In electricity industry with transmission constraints and limited number of producers, generation companies (GenCos) are facing an oligopoly market rather than a perfect competition one. Under oligopoly market environment, each GenCo may increase its own profit through a favourable bidding strategy. This paper investigates the problem of developing optimal bidding strategies of GenCos, considering bilateral contracts and transmission constraints. The problem is modelled with a bi-level optimization algorithm, where in the first level each GenCo maximizes its payoff and in the second level a system dispatch will be accomplished through an OPF problem in which transmission constraints are taken into account. It is assumed that each GenCo has information about initial bidding strategies of other competitors. Impacts of exercising market power due to transmission constraints as well as irrational biddings of the some generators are studied and the interactions of different bidding strategies on participants' corresponding payoffs are presented. Furthermore, a risk management-based method to obtain GenCos' optimal bilateral contracts is proposed and the impacts of these contracts on GenCos' optimal biddings and obtained payoffs are investigated. At the end, IEEE 30-bus test system is used for the case study in order to demonstrate the simulation results and support the effectiveness of the proposed model.

08/02614 Optimum sizing of battery-integrated diesel generator for remote electrification through design-space approach

Arun, P. *et al. Energy*, 2008, 33, (7), 1155–1168.

Battery integrated diesel generation is one of the options for decentralized power production. They are particularly suitable for loads with significant variation in the daily demand. A methodology for the optimum sizing of integrated system involving diesel generator and battery bank for an isolated electrical power generation is proposed in this paper. The proposed methodology is based on the design-space approach involving a time series simulation of the entire system. Based on the proposed approach, for a given load demand, characteristics of the diesel generator and battery bank, a sizing curve is identified on the diesel generator rating vs. storage capacity diagram. The sizing curve helps in identifying all possible feasible system configurations or the design space. Based on the minimum capital cost and the minimum operating cost of the system, the Pareto optimum curve is identified on the system-sizing curve. Optimum system configuration is identified based on the minimum cost of energy through optimal dispatch strategy. Two operating strategies, involving continuous and intermittent operation of the diesel generator are studied and compared. Effect of the load profile on the system sizing is also presented in this paper.

08/02615 Protection scheme for a distribution system with distributed generation using neural networks

Rezaei, N. and Haghifam, M.-R. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 235–241.

Interconnection of distributed generation (DG) to a radial distribution system has some impacts on the coordination of protection devices. In this case, faults are fed by multi-sources; networks and DGs. Existence of multi-sources in fault condition is the main difficulty in the identification and location of faults and therefore distribution system protection. New protection methods should be introduced for isolation of faulted sections. This paper presents a novel approach that can overcome the above problems. A feed forward neural network is used to identify the fault location. The predicted results from the algorithm prove the effectiveness of the proposed procedure for identifying fault location and then protection of the system for a wide range of system conditions.

08/02616 Reference models and incentive regulation of electricity distribution networks: an evaluation of Sweden's Network Performance Assessment Model (NPAM)

Jamasb, R. and Pollitt, M. *Energy Policy*, 2008, 36, (5), 1788–1801.

Electricity sector reforms across the world have led to a search for innovative approaches to regulation that promote efficiency in the natural monopoly distribution networks and reduce their service charges. To this aim, a number of countries have adopted incentive regulation models based on efficiency benchmarking. While most regulators have used parametric and non-parametric frontier-based methods of benchmarking some have adopted engineering-designed 'reference firm' or 'norm' models. This paper examines the incentive properties and related aspects of the reference firm model – NPAM – as used in Sweden and compares this with frontier-based benchmarking methods. A number of important differences between the two approaches are identified that are not readily apparent and discuss their ramifications for the regulatory objectives and process. It is concluded that, on balance, the reference models are less appropriate as benchmarks than real firms. Also, the implementation framework based on annual ex-post reviews exacerbates the regulatory problems mainly by increasing uncertainty and reducing the incentive for innovation.

08/02617 Reserve-constrained economic dispatch: cost and payment allocations

Misraji, J. *et al. Electric Power Systems Research*, 2008, 78, (5), 919–925.

This paper extends basic economic dispatch analytical results to the reserve-constrained case. For this extended problem, a cost and payment allocation analysis is carried out and a detailed economic interpretation of the results is provided. Sensitivity values (Lagrange multipliers) are also analysed. A case study is considered to illustrate the proposed analysis. Conclusions are duly drawn.

08/02618 Sequential time-step generation companies decisions in oligopolistic electricity market

Gutierrez-Alcaraz, G. *Electric Power Systems Research*, 2008, 78, (5), 824–834.

This paper studies the production decisions of generation companies (GENCOs) which are fully engaged in oligopolistic electricity markets. The model presented is based upon the static equilibrium model solved sequentially in time. By decomposing the problem in time, each time-step is solved independently using a Cournot-like market model. The time dimension is divided into discrete, 1-h time-steps. The model also incorporates the effects of technical and temporal constraints such as time on/off and ramp up/down. Since GENCOs tend toward repetitive decision-making, they can more easily learn from the market. The concept of forward expectations and the lessons derived from the market are introduced, and several numerical examples are provided.

08/02619 Simple and fast fabrication of polymer template-Ru composite as a catalyst for hydrogen generation from alkaline $NaBH_4$ solution

Hsueh, C.-L. *et al. Journal of Power Sources*, 2008, 177, (2), 485–492.

Polymer template-Ru composite (Ru/IR-120) catalyst was prepared using a simple and fast method for generating hydrogen from an aqueous alkaline $NaBH_4$ solution. The hydrogen generation rate was determined as a function of solution temperature, $NaBH_4$ concentration, and NaOH (a base-stabilizer) concentration. The maximum hydrogen generation rate reached $132\,ml\,min^{-1}\,g^{-1}$ catalyst at 298 K, using a Ru/IR-120 catalyst that contained only 1 wt.% Ru. The catalyst exhibits a quick response and good durability during the hydrolysis of alkaline $NaBH_4$ solution. The activation energy for the hydrogen generation reaction was determined to be $49.72\,kJ\,mol^{-1}$.

08/02620 The influence of temperature on spike probability in day-ahead power prices

Huisman, R. *Energy Economics*, 2008, 30, (5), 2697–2704.

It is well known that day-ahead prices in power markets exhibit spikes and time-varying volatility. Spikes and extremely high volatility are the results of (short-term) frictions in demand and/or supply conditions. It is known that information on load or the reserve margin help to forecast spikes. However, these variables are not (timely) available for every market participant and this paper suggests to use temperature as a proxy. Interpreting the results from several switching-regimes models, the paper shows that the probability of spike occurrence increases when temperature deviates substantially from mean temperature levels.

08/02621 The optimal size for biogas plants

Walla, C. and Schneeberger, C. *Biomass and Bioenergy*, 2008, 32, (6), 551–557.

The costs of biogas and electricity production from maize silage in relation to plant size are investigated in this paper. A survey of manufacturers' engineering data was conducted to derive a reliable relationship between the capacity of a combined heat and power unit and its electrical efficiency. Then a model was developed to derive cost curves for the unit costs of biogas and electricity production and for the transport costs for maize silage and biogas slurry. The least-cost plant capacity depends to a great extent on the local availability of silage maize, and ranges in the model calculations from 575 to $1150\,kW_{el}$. Finally, the paper deals with the optimum operating plant size due to the investment support available and the graduated tariff for green electricity in Austria.

08/02622 Thermodynamic analysis of the efficiency of high-temperature steam electrolysis system for hydrogen production

Liu, M. *et al. Journal of Power Sources*, 2008, 177, (2), 493–499.

High-temperature steam electrolysis (HTSE), a reversible process of solid oxide fuel cell (SOFC) in principle, is a promising method for highly efficient large-scale hydrogen production. In the study, the overall efficiency of the HTSE system was calculated through electrochemical and thermodynamic analysis. A thermodynamic model in regards to the efficiency of the HTSE system was established and the quantitative effects of three key parameters, electrical efficiency (η_{el}), electrolysis efficiency (η_{es}), and thermal efficiency (η_{th}) on the overall efficiency ($\eta_{overall}$) of the HTSE system were investigated. Results showed that the contribution of η_{el}, η_{es}, η_{th} to the overall efficiency were about 70%, 22%, and 8%, respectively. As temperatures increased from 500 °C to 1000 °C, the effect of η_{el} on η_{overall} decreased gradually and the η_{es} effect remained almost constant, while the η_{th} effect increased gradually. The overall efficiency of the high-temperature gas-cooled reactor (HTGR) coupled with the HTSE system under different conditions was also calculated. With the increase of electrical, electrolysis, and thermal efficiency, the overall efficiencies were anticipated to increase from 33% to a maximum of 59% at 1000 °C, which is over two times higher than that of the conventional alkaline water electrolysis.

07 STEAM RAISING

Boiler operation/design

08/02623 Distributed parameter modeling and simulation for the evaporation system of a controlled circulation boiler based on 3-D combustion monitoring

Chu, Y. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 164–177.

In this paper, a dynamic, distributed parameter model for the evaporation system of a controlled circulation boiler was developed. As an essential basis, the three-dimensional temperature distribution and the average emissivity of the particle phase inside its furnace can be obtained using a flame image processing technique from multiple, visible flame image detectors in a real-time combustion monitoring system. Then the transient, two-dimensional radiation flux can be obtained by solving a set of energy balance equations for the water wall elements, which serves as a distributed boundary condition for the dynamic, distributed parameter model proposed for the evaporation system. For large change of the boiler load, two important parameters, the correction factor of equivalent flame emissivity and the coefficient of the steam mass flow rate at the outlet of the drum, were determined using the operation data from a 300 MW boiler. The model was validated by comparing the simulation results for some main steam parameters of the system with those from measurements. Besides that, the transient distributions of the parameters, such as the steam quality and the mass velocity, were predicted by the model. This model can be used for on-line calculation or off-line prediction of the local abnormal phenomena occurring on the water walls, forming an important basis to effectively evaluate the security and the reliability of a power plant boiler.

08/02624 Experimental validation of the helical steam generator model in the TASS/SMR code

Yang, S. H. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 49–59.

The transients and setpoint simulation/system-integrated modular reactor (TASS/SMR) code has been used to identify the safety margin of a 65-MWt advanced integral reactor and to evaluate its design performance. Although, the code has been verified by using simplified and analytical problems as well as a reliable system code, its validation has not been fully established. This paper deals with a validation of the TASS/SMR code by using two kinds of separate effect tests related to heat transfer at a helically coiled steam generator. The heat transfer experiments were performed by using a full-scale prototype of the steam generator cassette of the advanced integral reactor and a scaled-down steam generator cassette. Analytical results show that the TASS/SMR code predicts the thermal hydraulic parameters, including the system pressure and fluid temperature at the primary and secondary sides of the steam generator cassette, and the heat transfer rate through the steam generator cassette well. The validation results in this study show that the TASS/SMR code is applicable for heat transfer calculations related to the helically coiled steam generator of the advanced integral reactor.

08/02625 Study on the mechanism of unsteady combustion related to volatile in a coal-fired traveling grate boiler

Ji, J. J. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 145–156.

There are a variety of low-grade and hard-to-burn coals used in grate boilers in China. Almost all of them are manufactured with arches to promote the efficiency and their applicability to various coals. However, those boilers sometimes suffer from the unsteady combustion known as ‘puff’, which degrades energy efficiency, emits smoke pollution and even damages components. The mechanism responsible for its occurrence has been speculated to be related to the abnormal combustion of volatile released from coal, however, the details have not been clearly known up till now. In this paper, an experimental system is set up to investigate the unsteady combustion mechanism in an industrial traveling grate boiler. Natural gas is used to simulate the volatile from coal. Under the condition of two typical air distribution modes, dynamic pressure signals at various flow rates with fixed stoichiometric ratio are measured and influence factors on the unsteady combustion are studied. The detailed combustion characteristics are analysed with large eddy simulation. The simulation is in reasonable agreement with the experiment and further discovers the mechanism of the volatile-related unsteady combustion. Moreover, the frequency analysis of the experimental data also confirms this mechanism.

08 COMBUSTION

Burners, combustion systems

08/02626 A pilot-scale fireside deposit study of co-firing Cynara with two coals in a fluidised bed

Aho, M. *et al. Fuel*, 2008, 87, (1), 58–69.

Costs of biofuel production from energy crops can be reduced by applying the crop residues in heat and power production. Perennial herbaceous crops like *Cynara cardunculus L.* are challenging fuels because they tend to have high ash and chlorine contents. Coals, however, are often rich in aluminium silicates and sulfur, and co-firing of these biofuels with coal could be expected to reduce operational problems. In addition, CO_2 emissions are lower than during coal firing alone. Blends of Cynara and two coals, South African bituminous and Spanish sub-bituminous coal, were combusted in a 20 kW bubbling bed pilot reactor to ascertain the ability of the coals to reduce operational problems by alkali capture. The Cynara fuel sample contained almost 2 wt% chlorine. The South African coal was rich in kaolinite capable of capturing alkalies from chlorides to produce alkali aluminium silicate and HCl. The Spanish coal was rich in sulfur (mostly present as FeS_2), and produced high concentrations of SO_2 that partially oxidized to SO_3. The SO_3 can capture alkalis from chlorides by sulphation. Up to 30% Cynara, on energy basis, could be co-fired with Spanish coal without operational problems, whereas the same percentage of Cynara with South African coal led to strong Cl deposition. Co-firing of Cynara with both coals resulted in high HCl emissions (up to 1500 mg/Nm^3 in 6% O_2). In addition, co-firing of the Spanish coal led to very high SO_2 emissions (up to about 16,000 mg/N m^3 in 6% O_2). Thus, a power plant capable of firing such blends must be equipped with flue gas cleaning equipment for effective SO_2 and HCl capture in the flue gas channel after the superheaters, or else the quality of the Cynara must be markedly improved by changing the harvesting technology and fertilizers, which could be major sources of high ash and chlorine content in the fuel.

08/02627 A study of a ceria–zirconia-supported manganese oxide catalyst for combustion of Diesel soot particles

Escribano, V. S. *et al. Combustion and Flame*, 2008, 153, (1–2), 97–104.

A study has been conducted on the structural and morphological characterization of a Ce–Zr mixed oxide-supported Mn oxide as well as on its catalytic activity in the oxidation of particulate matter arising from Diesel engines. X-ray powder diffraction analysis and FT-IR and FT-Raman spectroscopy evidence that the support is a fluorite-like ceria–zirconia solid solution, whereas the supported phase corresponds to the manganese oxide denoted as bixbyite ($-Mn_2O_3$). Thermal analyses and FT-IR spectra in air at varying temperatures of soot mechanically mixed with the catalyst evidence that the combustion takes place to a total extent in the range 420–720 K, carboxylic species being detected as intermediate compounds. Moreover, the soot oxidation was studied in a flow reactor and was found to be selective to CO_2, with CO as by-product in the range 420–620 K. The amount of the generated CO decreases significantly with increasing O_2 concentration in the feed.

08/02628 Alkali/chloride release during refuse incineration on a grate: full-scale experimental findings

Bøjer, M. *et al. Fuel Processing Technology*, 2008, 89, (5), 528–539.

Waste to energy (WtE) plants are utilized for the production of heat and electricity. However, due to corrosion at super heater surfaces a relatively low 25% of the waste lower heating value can with the present technology be converted to electricity. High contents of Cl, Na, K, Zn, Pb and S in waste cause relatively high super heater corrosion rates. The Cl-content in waste is one of the key-factors for volatilization of alkali and heavy metals in WtE plants. Little is known about the release of Cl, Na, K, Zn, Pb, and S along grate of waste incineration plants. The 26 t h^{-1} WtE plant Vestforbrænding unit 5 in Denmark was used for measurements of temperature, gas-concentration (O_2/CO/CO_2), and sampling of gas phase Cl, Na, K, Pb, Zn, and S. Unit 5 has six ports distributed along the 13 m long grate between 1.5–1.8 m above the grate. Five of these ports were used for measurements. Two aqueous absorption systems containing a solution of NH_3 or a solution of H_2O_2/HNO_3 were used to collect the gaseous samples. Tar was found to condense in the sampling system at the ports near the fuel inlet. The experiments showed the majority of Cl, Na, and K to be volatilized during the early stages of combustion. The maximum release of Cl, Na, and K was measured in port 2 as 177 ppm$_v$, 71 ppm$_v$, and 44 ppm$_v$ respectively. The maximum average gas temperature of 1140 was measured in port 3 compared to the temperatures at ports 2 and 4 of 816 and 551 respectively. It has been suggested to use flue gas from the area of the grate near port 3 with a high temperature, that contains relatively low amounts of corrosive elements, and lead to a separate high temperature super heater and thus increase the electrical efficiency.

08/02629 An experimental investigation of ethylene/O_2/diluent mixtures: laminar flame speeds with preheat and ignition delays at high pressures

Kumar, K. *et al. Combustion and Flame*, 2008, 153, (3), 343–354.

The atmospheric pressure laminar flame speeds of premixed ethylene/O_2/N_2 mixtures were experimentally measured over equivalence ratios ranging from 0.5 to 1.4 and mixture preheat temperatures varying from 298 to 470 K in a counterflow configuration. Ignition delay measurements were also conducted for ethylene/O_2/N_2/Ar mixtures using a rapid compression machine at compressed pressures from 15 to 50 bar and in the compressed temperature range from 850 to 1050 K. The experimental laminar flame speeds and ignition delays were then compared to the computed values using two existing chemical kinetic mechanisms. Results show that while the laminar flame speeds are reasonably predicted at room temperature conditions, the discrepancy becomes larger with increasing preheat temperature. A comparison of experimental and computational ignition delay times was also conducted and discussed. Sensitivity analysis further shows that the ignition delay is highly sensitive to the reactions of the vinyl radical with molecular oxygen. The reaction of ethylene with the HO_2 radical was also found to be important for autoignition under the current experimental conditions.

08/02630 Autoignition of *n*-decane at high pressure

Zhukov, V. P. *et al. Combustion and Flame*, 2008, 153, (1–2), 130–136.

The ignition of *n*-decane in air has been studied experimentally at temperatures between 800 and 1300 K and at pressures up to 80 atm. The experiments have been carried out in a preheated shock tube. Ignition delay times of stoichiometric and lean mixtures of *n*-decane and air have been measured behind reflected shock waves. The experimental data have been compared with four kinetic mechanisms. Differences between the experimental data and the modelling results are discussed.

08/02631 Combustion of bio-oil ethanol blends at elevated pressure

Nguyen, D. and Honnery, D. *Fuel*, 2008, 87, (2), 232–243.

This paper reports an investigation on the combustion performance of bio-oil/ethanol blends. Experiments were conducted in a constant volume vessel operating at a pressure of 25 bar and temperature 1100 K. Bio-oil produced via the fast pyrolysis of a spruce feedstock was blended to ethanol to form three stable blends containing 10%, 20% and 40% bio-oil by weight. In addition, ethanol and standard automotive grade diesel were tested as reference fuels. Measured vessel pressure was used in a single-zone heat release analysis, while two-colour optical pyrometry was used to investigate particle loading and temperature. Results show that for similar injections of fuel energy, use of up to 20% bio-oil in ethanol has limited impact on the performance of ethanol while 40% bio-oil in ethanol produced instability in the pressure trace near the end of the combustion process. Burning rates are similar for blends and ethanol. Addition of bio-oil to ethanol was found to increase combustion generated particle load, and this increased with bio-oil concentration, but remained much lower than particle concentration in diesel. Addition of bio-oil also resulted in formation of char particles that appear as luminous clusters outside the boundary of the spray. This suggests these particles will cool rather than oxidize. The presence of unburnt char particles in large numbers may have consequences for bio-oil as an alternative diesel fuel.

08/02632 Computer modelling of the combined effects of plant conditions and coal quality on burnout in utility furnaces

Stephenson, S. *Fuel*, 2007, 86, (14), 2026–2031.

The aim of this paper is to describe the latest steps in the development of a computer model to predict the combined effects of plant conditions and coal quality on burnout. The work was conducted as part of RWE's contribution to the recent ECSC project 'Development of a carbon-in-ash notification system (CARNO)'. A burnout predictor code has been developed and validated; it includes both coal and plant effects and includes a burnout model based closely on CBK8. The agreement between predicted carbon-in-ash and plant data is encouraging, but further improvements are still desirable. The predictions obtained from the burnout predictor show that the calculated sensitivities to changes in plant condition can be very dependent on state of plant.

08/02633 Effect of carbon dioxide on flame propagation of pulverized coal clouds in CO_2/O_2 combustion

Suda, T. *et al. Fuel*, 2007, 86, (12–13), 2008–2015.

CO_2/O_2 combustion of pulverized coal is one of the promising new technology in order to reduce the emission of CO_2 and NO_x from coal combustion furnaces. However, several experiments with pulverized coal burners show that temperature and stability of pulverized coal flame is reduced in this condition. CO_2 has distinctive thermodynamic and optical property compared with that of other gas, and it is important to know the effect of CO_2 on the flame stability of pulverized coal. In this study, effect of CO_2 on flame propagation velocity of pulverized coal clouds were studied experimentally using micro-gravity condition, and also numerically considering detailed radiation heat exchange using Monte Carlo method. Experiments were made by using spherical chamber with inner diameter of 200 mm. Micro-gravity condition was used in order to achieve uniform pulverized coal cloud in a chamber. Flame propagation velocity was measured from the photographic image of the flame front by using a high-speed camera. Results show that flame propagation velocity of pulverized coal cloud in CO_2/O_2 mixture gas decreases to about 1/3–1/5 of that in N_2/O_2 mixture gas at the same oxygen concentration. By using Ar/O_2 mixture gas, it is revealed that thermal diffusivity of gas seems to have a large effect on flame propagation velocity. From the numerical analysis using Monte Carlo method, effect of absorption of radiation by CO_2 gas is proven to be relatively small compared with that of thermodynamic property especially for heat capacity of CO_2. Consequently, it is clarified that reduction of flame stability in CO_2/O_2 combustion is mainly due to the larger heat capacity of CO_2 gas.

08/02634 Experimental studies on cotton stalk combustion in a fluidized bed

Sun, Z. *et al. Energy*, 2008, 33, (8), 1224–1232.

The present work reports studies on the mixing and combustion characteristics of cotton stalk (CS) with 10–100 mm in length in a fluidized bed. Effects of length and initial weight percentage of CS, diameter of alumina bed material as well as gas velocity on the mixing characteristics of CS with alumina were investigated. CS can mix well with 0.6–1 mm alumina at fluidization number $N = 3$–8. Fluidized bed combustion of pure CS was conducted in a 0.2 MW$_{th}$ test facility. The concentrations of major gaseous pollutants (CO, SO_2 and NO) in flue (stack) gas were measured. The combustion efficiency of CS is over 99.5%. Additionally, the experiments researched the agglomeration characteristics of bed materials: silica sand and alumina. SEM/EDX analyses on silica samples suggest that the high alkali metals content may cause the formation of the coating around silica particles. The coating consists of compounds with low melting temperature and can result in the bed agglomeration. By contrast, alumina is difficult to react with alkali metals from CS ash after 38 h combustion.

08/02635 Experimental study on cotton stalk combustion in a circulating fluidized bed

Sun, Z.-A. *et al. Applied Energy*, 2008, 85, (11), 1027–1040.

This paper summarizes the results of an experimental study on cotton stalk (CS) combustion in a circulating fluidized bed. The mixing and fluidizing characteristics of binary mixture of CS with 10–100 mm in length and alumina bed material with a certain size distribution in a cold test facility were studied. The results show that CS by itself cannot fluidize, and adding inert bed material can improve the fluidization condition. CS can mix well with alumina at fluidization number $N = 3$–7. As N is more than 7, there will exist a little more segregation. The study concerning combustion characteristics of pure CS was performed on a circulating fluidized bed with a heat input of 0.5 MW. The effects of fluidizing velocity, secondary air flow and gas flow to the loop seal on the bed temperature profiles were investigated. Although there is a little more segregation at N higher than 7 in the cold tests, the hot experimental results indicate that slight segregation has little effect on the steady combustion of the dense region. In this study, the concentrations of major gaseous pollutants (CO, SO_2 and NO) in flue (stack) gas were measured.

08/02636 Flammability and rheological behavior of mixed flame retardant modified asphalt binders

Wu, S. *et al. Fuel*, 2008, 87, (1), 120–124.

The flammability and rheological behaviour of asphalt modified by mixed flame retardants was investigated using differential scanning calorimetry and dynamic shear rheometer, respectively. The mixed flame retardants used consisted of decabromodiphenyl ether, antimony trioxide and aluminium trihydroxide with the ratio of 3:1:1 by mass. Experimental results indicated that the inclusion of 6 wt% mixed flame retardants improves the flame retardancy significantly by consuming the released heat of asphalt in a temperature range of 300–500 °C. The close values of the activation energy obtained by fitting Arrhenius model demonstrate flame retardant modified asphalt exhibits similar thermal susceptibility to base asphalt in the temperature range of 30–100 °C. It can foresee that the content of flame retardant is expected to increase with respect to better flame resistance if required based upon this research.

08/02637 Flow processes in a radiant tube burner: isothermal flow

Tsioumanis, N. *et al. Fuel*, 2008, 87, (1), 103–111.

This paper presents the first part of a study of the combustion processes in an industrial radiant tube burner (RTB). The RTB is used typically in heat-treating furnaces. The work was initiated because of the need for improvements in burner lifetime and performance. The present paper is concerned with the flow of combustion air; a future paper will address the combusting flow. A detailed three-dimensional computational fluid dynamics model of the burner was developed, validated with experimental air flow velocity measurements using a split-film probe. Satisfactory agreement was achieved using the k–ε turbulence model. Various features along the air inlet passage were subsequently analysed. The effectiveness of the air recuperator swirler was found to be significantly compromised by the need for a generous assembly tolerance. Also, a substantial circumferential flow maldistribution introduced by the swirler is effectively removed by the positioning of a constriction in the downstream passage.

08/02638 Porous burners for lean-burn applications

Wood, S. and Harris, A. T. *Progress in Energy and Combustion Science*, 2008, 34, (5), 667–684.

In this paper, research is reviewed on lean methane combustion in porous burners, with an emphasis on practical aspects of burner design and operation and the application of the technology to real-world problems. In particular, focus is on 'ultra-lean' combustion, where the methane concentration is actually at or below the lean flammability limit for a free flame (5% methane by volume in air). Porous burners are an advanced combustion technology whereby a premixed fuel/air mixture burns within the cavities of a solid porous matrix. They are capable of burning low-calorific value fuels and very lean fuel/air mixtures that would not normally be flammable, potentially allowing the exploitation of what would otherwise be wasted energy resources. Possible lean-burn applications include the reburn of exhaust gases from existing combustion systems, and the mitigation of fugitive methane emissions. Porous burners operate on the principle that the solid porous matrix serves as a means of recirculating heat from the hot combustion products to the incoming reactants. This results in burning velocities higher than those for a free flame, as well as extended lean flammability limits. Burner performance is also characterized by low emissions of combustion related pollutants and stable operation over a wide range of fuel concentrations and flow rates. Stable combustion of methane/air mixtures below the conventional lean limit has been observed by a number of researchers; in one study the combustion of a mixture with a fuel concentration of only 1% was reported. A number of design considerations are important as regards optimizing burner performance for lean-burn applications. Foremost among these is the selection of a suitable material for the porous matrix. Other potentially significant design issues include the length of the porous bed, the use of 'multi-section' designs where different porous materials are used in each section, the incorporation of external heat exchangers to supplement the heat recirculation provided by the porous matrix, and the ability to operate the burner at elevated pressures. The majority of previous studies have been directed towards the use of porous burners for radiant heating applications rather than for the combustion of low-calorific value fuels. Consequently there is a lack of reliable data relating specifically to ultra-lean combustion. Further research is required to progress this field, for example on the influence on burner performance of the design considerations listed above, the stability of the combustion process to fluctuations in fuel concentration and flow rate, the development of reliable models specifically for ultra-lean combustion in practical burners, and the investigation of issues relating to scale-up and commercial application.

08/02639 Progress in miniature liquid film combustors: double chamber and central porous fuel inlet designs

Li, Y.-H. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (5), 1118–1131.

One of the key limits to miniaturizing the size of liquid fueled combustors is the atomization process applied in meso-scale systems. A single-wall fuel-film combustor was introduced recently as one of the successful liquid fuel combustors at the meso-scale. Instead of atomizing the fuel, film combustors spread out a liquid film along the wall and absorb the heat transferred from the flame for vaporization. With a single-wall film design, however, there are some unexpected and disadvantageous combustion phenomena. This paper attempts to improve the single-wall film combustor by exploring separately a double chamber concept and a central porous fuel delivery concept. These two configurations help describe the limits and the potential of liquid fuel-film miniature combustors. The double chamber design demonstrates how heat transfer issues can be overcome by injecting the fuel-film on the outside of the primary combustor wall rather than on the inside, and the second design demonstrates a flame-holding mechanism using a porous material set on the bottom of the chamber. The combustion behaviour in these two configurations is compared with that in the original single-wall miniature fuel-film combustor, revealing new aspects that are relevant to portable power generation with high specific energy and power.

08/02640 Removal of elemental mercury from simulated coal-combustion flue gas using a SiO_2–TiO_2 nanocomposite

Li, Y. *et al. Fuel Processing Technology*, 2008, 89, (6), 567–573.

A novel silica–titania (SiO_2–TiO_2) nanocomposite has been developed to effectively capture elemental mercury (Hg^0) under UV irradiation. Previous studies under room conditions showed over 99% Hg^0 removal efficiency using this nanocomposite. In this work, the performance of the nanocomposite on Hg^0 removal was tested in simulated coal-fired power plant flue gas, where water vapour concentration is much higher and various acid gases, such as HCl, SO_2, and NO_x, are present. Experiments were carried out in a fix-bed reactor operated at 135 °C with a baseline gas mixture containing 4% O_2, 12% CO_2, and 8% H_2O balanced with N_2. Results of Hg speciation data at the reactor outlet demonstrated that Hg^0 was photocatalytically oxidized and captured on the nanocomposite. The removal efficiency of Hg^0 was found to be significantly affected by the flue gas components. Increased water vapour concentration inhibited Hg^0 capture, due to the competitive adsorption of water vapour. Both HCl and SO_2 promoted the oxidation of Hg^0 to Hg(II), resulting in higher removal efficiencies. NO was found to have a dramatic inhibitory effect on Hg^0 removal, very likely due to the scavenging of hydroxyl radicals by NO. The effect of NO_2 was found to be insignificant. Hg removal in flue gases simulating low rank coal combustion products was found to be less than that from high rank coals, possibly due to the higher H_2O concentration and lower HCl and SO_2 concentrations of the low rank coals. It is essential, however, to minimize the adverse effect of NO to improve the overall performance of the SiO_2–TiO_2 nanocomposite.

08/02641 Reynolds analogy in combustor modeling

Jiang, L.-Y. and Campbell, I. *International Journal of Heat and Mass Transfer*, 2008, 51, (5–6), 1251–1263.

The Reynolds analogy concept has been used in almost all turbulent reacting flow Reynolds-averaged Navier–Stokes simulations, where the turbulence scalar transfers in flow fields are calculated based on the modelled turbulence momentum transfer. This concept, applied to a diffusion flame model combustor, is assessed in this paper. Some of the numerical results, obtained from a flamelet combustion model with the turbulent Prandtl/Schmidt number varying from 0.25 to 0.85, are presented and compared with a benchmark experimental database. It is found that the turbulent Prandtl/Schmidt number has significant effects on the predicted temperature and species fields in the combustor. This is also true for the temperature profile along the combustor wall. In contrast, its effect on the velocity field is insignificant in the range considered. With an optimized turbulent Prandtl/Schmidt number, both velocity and scalar fields can be reasonably and quantitatively predicted. For the present configuration and operating conditions, the optimal Prandtl/Schmidt number is 0.5, lower than the traditionally used value of 0.85. This study suggests that for accurate prediction of turbulence scalar transfers in practical reacting flows, the Reynolds analogy concept should be improved and new approaches should be developed.

08/02642 Simulation of spray–turbulence–flame interactions in a lean direct injection combustor

Patel, N. and Menon, S. *Combustion and Flame*, 2008, 153, (1–2), 228–257.

Large-eddy simulation (LES) of a liquid-fueled lean-direct injection combustor is carried out by resolving the entire inlet flow path through the swirl vanes and the combustor. A localized dynamic subgrid closure is combined with a subgrid mixing and combustion model so that no adjustable parameters are required. The inflow spray is specified by a Kelvin–Helmholtz (or aerodynamic) breakup model and compared with LES without breakup, where the incoming spray is approximated using measured data just downstream of the injector. Overall, both time-averaged gas and droplet velocity predictions compare well with the measured data. The major impact of breakup is on fuel evaporation in the vicinity of the injector. Further downstream, a broad spectrum of drop sizes are recovered by the breakup simulation and produces spray quality, as in the no-breakup case. It is shown that the vortex breakdown bubble (VBB) is smaller with more intense reverse flow when there is heat release. The swirling shear layer plays a major role in spray dispersion and the VBB provides an efficient flame-holding mechanism to stabilize the flame. Unsteady features such as the efficient dispersion of the spray by the precessing vortex core are well captured. Flame structure analysis using the Takeno flame index shows the presence of a diffusion flame in the central portion, whereas premixed burning mode is observed farther away. Instantaneous thermochemical states of fuel–air mixing and oxidation indicate significant departure from the gaseous diffusion limits, consistent with earlier observations. Additionally, particle–particle and particle–gas correlations are analysed and discussed.

08/02643 Soret transport, unequal diffusivity, and dilution effects on laminar diffusion flame temperatures and positions

Arias-Zugasti, M. and Rosner, D. E. *Combustion and Flame*, 2008, 153, (1–2), 33–44.

Since, according to ideal gas kinetic theory, Ludwig–Soret species transport (temperature-gradient-driven mass transport) must be simultaneously included along with non-unity Lewis numbers, the authors formally consider here the influence of both effects on laminar, counterflow gaseous diffusion flames in the thin flame limit. The deliberately idealized theoretical analysis includes cases of steady/unsteady, strained/unstrained flames and formally permits the prediction of trends for the combustion of either light or heavy fuel vapours in O_2-containing streams. The results suggest that, in cases of low- or high-molecular-weight gaseous fuels, Ludwig–Soret transport can itself introduce significant shifts in flame position and flame temperature, compared to results of the same mathematical model neglecting Soret fuel-vapour transport but including only nonunity fuel Lewis numbers. These systematic shifts (which in specific cases may have to be supplemented by additional corrections due to variable thermophysical properties) are expected to have important consequences for NO_x production and/or infrared radiation emission.

08/02644 Surface-enhanced Raman scattering study of nano-sized organic carbon particles produced in combustion processes

Rusciano, G. *et al. Carbon*, 2008, 46, (2), 335–341.

Surface-enhanced Raman scattering (SERS) has been employed for the first time to characterize nano-sized organic carbon (NOC) particles produced in ordinary combustion processes. Ag-coated glass microparticles, used as SERS substrate, provide a Raman scattering cross section enhancement up to five orders of magnitude, which allows sample investigation at low concentration level. The observed spectral features supply a deeper insight on the chemical properties of the investigated combustion product. In addition, the high sensitivity of the SERS technique might be useful to test and characterize the toxicity of NOC particles.

08/02645 Thermal cracking of recycled hydrocarbon gas-mixtures for re-pyrolysis: operational analysis of some industrial furnaces

Gál, T. and Lakatos, B. G. *Applied Thermal Engineering*, 2008, 28, (2–3), 218–225.

Thermal decomposition process of recycled hydrocarbon gas-mixtures in industrial furnaces is analysed by computer simulation. The detailed kinetic and mathematical model developed was validated by using the process control laboratory cracked gas analysis of an industrially operated furnace. The effects of feed compositions and operational conditions are examined to select the favourable operating parameters and to achieve the possibly highest online operation period of the furnace. The effect of deposited coke on the lifetime of radiant coils is examined by a heat-transfer model. The simulation study confirmed that temporal variations of the feedstock composition could be harmonized well with the operating parameters of furnaces with the purpose of achieving maximum effectiveness.

08/02646 Thermal decomposition of pyrotechnic mixtures containing either aluminum or magnesium powder as fuel

Pourmortazavi, S. M. *et al. Fuel*, 2008, 87, (2), 244–251.

Thermal behaviour of energetic materials is critical to safe production, storage, handling or even demilitarization. In this work, the thermal behaviour of Al, Mg, CuO, $KMnO_4$ and also three mixtures containing Al + CuO, Mg + CuO and Mg + $KMnO_4$ were studied experimentally using differential scanning calorimetry and thermogravimetry. These mixtures are sometimes used as pyrotechnic mixtures in military industries. Also, the influence of different heating rates (5, 10, 15 and 20 °C/min) on the DSC behaviour of the mixtures was verified. The results showed that as the heating rate was increased, melting points and ignition temperatures of the mixtures were increased. On the other hand, TG–DSC analysis for Mg + $KMnO_4$ mixture indicates that this mixture melts at 283.0 °C and decomposed at 292.1 °C. By replacing $KMnO_4$ with CuO as the oxidizer of the magnesium, these temperatures enhanced to 368.7 °C and 408.3 °C, respectively. However, replacing Mg with Al in the Mg/CuO mixture decreases the melting and ignition temperatures of the mixture to 231.4 °C and 271.9 °C, respectively. The activation energy for each pyrotechnic mixture was computed. Also, the values of $\Delta S^{\#}$, $\Delta H^{\#}$ and $\Delta G^{\#}$ of their reaction were calculated.

08/02647 Understanding the pyrolysis of CCA-treated wood part II. Effect of phosphoric acid

Fu, Q. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 140–144.

The pyrolysis process of chromated copper arsenate (CCA)-treated wood impregnated with phosphoric acid (2–6 wt.%) has been investigated using a Kugelrohr short-path distillation apparatus. The presence of phosphoric acid is shown to change the overall pyrolysis kinetics and yields of products resulting in a decrease in the amount of volatile products and an increase in the char formation. The yield of levoglucosan was found to decrease in the presence of relatively higher concentrations of phosphoric acid, while the yield of levoglucosenone increased. The pyrolysis of chromated copper arsenate-treated wood in the presence of phosphoric acid gave rise to 22% (on water-free tar basis) levoglucosenone. Such data demonstrates the potential for a new pathway toward the rational utilization of chromated copper arsenate-treated wood waste.

Fire safety

08/02648 An experimental study on the effect of ventilation velocity on burning rate in tunnel fires – heptane pool fire case

Roh, J. S. *et al. Building and Environment*, 2008, 43, (7), 1225–1231.

The one-twentieth reduced-scale experiments using Froude scaling are conducted to investigate the effect of longitudinal ventilation velocity on the burning rate in tunnel fires. The n-heptane pool fires with heat release rate ranging from 3.71 to 15.6 kW are used in this study. A load cell is used to measure the mass loss rate of burning fuel and the temperature distributions are measured by K-type thermocouples in order to investigate smoke movement. The ventilation velocity in the reduced-scale tunnel is controlled by the wind tunnel through an inverter. The increases in ventilation velocity lead to enhance burning rate of n-heptane fuel. The reason is that the oxygen supply effect prevails rather than the cooling effect as the ventilation velocity increases. As a result, the heat release rates in experiment are larger than constant heat release rates by 4.45–11.3 times in the *n*-heptane pool fires. Also, it is found that non-dimensional critical ventilation velocity is proportional to one-third power of non-dimensional heat release rate.

08/02649 Numerical modeling for analyzing thermal surface anomalies induced by underground coal fires

Wessling, S. *et al. International Journal of Coal Geology*, 2008, 74, (3–4), 175–184.

Coal seams burning underneath the surface are recognized all over the world and have drawn increasing public attention in the past years. Frequently, such fires are analysed by detecting anomalies like increased exhaust gas concentrations and soil temperatures at the surface. A proper analysis presumes the understanding of involved processes, which determine the spatial distribution and dynamic behaviour of the anomalies. In this paper, the relevance of mechanical and energy transport processes are explained with respect to the occurrence of temperature anomalies at the surface. Two approaches are presented, aiming to obtain insight into the underground coal fire situation: *in situ* temperature mapping and numerical simulation. In 2000 to 2005, annual temperature mapping in the Wuda (Inner Mongolia, People's Republic of China) coal fire area showed that most thermal anomalies on the surface are closely related to fractures, where hot exhaust gases from the coal fire are released. Those fractures develop due to rock mechanical failure after volume reduction in the seams. The measured signals at the surface are therefore strongly affected by mechanical processes. More insight into causes and effects of involved energy transport processes is obtained by numerical simulation of the dynamic behaviour of coal fires. Simulations show the inter-relation between release and transport of thermal energy in and around underground coal fires. The simulation results show a time delay between the coal fire propagation and the observed appearance of the surface temperature signal. Additionally, the overall energy flux away from the burning coal seam into the surrounding bedrock is about 30-times higher than the flux through the surface. This is of particular importance for an estimation of the energy released based on surface temperature measurements. Finally, the simulation results also prove that a fire propagation rate estimated from the interpretation of surface anomalies can differ from the actual rate in the seam.

08/02650 Possible use of non-flammable phosphonate ethers as pure electrolyte solvent for lithium batteries

Feng, J. K. *et al. Journal of Power Sources*, 2008, 177, (1), 194–198.

Dimethyl methyl phosphonate (DMMP) was selected and tested as a non-flammable solvent for primary and secondary lithium batteries, because of its non-flammability, good solvency of lithium salts and appropriate liquid properties. Experimental results demonstrated that DMMP can solvate considerable amount of commonly used lithium salts to form non-flammable and Li^+-conducting electrolyte, which has very wide electrochemical window (>5 V vs. Li) and excellent electrochemical compatibility with metallic lithium anode and oxide cathodes. Primary Li–MnO_2 cells using DMMP-based electrolyte showed almost the same discharge performances as those using organic carbonate electrolytes, and also, Li–$LiMn_2O_4$ cells using DMMP electrolyte exhibited greatly improved cycleability and dischargeability, suggesting a feasible application of this new electrolyte for constructing high performance and non-flammable lithium batteries.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

08/02651 A computational fluid dynamics study of propane/air microflame stability in a heat recirculation reactor

Federici, J. A. and Vlachos, D. G. *Combustion and Flame*, 2008, 153, (1–2), 258–269.

The stability of a single-pass heat recirculation microburner is studied using computational fluid dynamics and compared to a single channel (no recirculation) with respect to critical heat loss coefficient, power loss, and critical inlet velocity. The effects of reactor length and outer wall thickness are also explored. It is shown that heat recirculation profoundly affects blowout due to preheating of the cold incoming gases but has a minimal effect on extinction. The inner wall of the heat recirculation microburner is found to more strongly impact stability than the outer wall, with most stable burners having both walls (inner and outer) insulated. Under certain conditions, the heat recirculation reactor can operate with moderate outer wall temperatures and room-temperature inlet and outlet streams while exhibiting high thermal efficiency.

08/02652 A consistent geochemical modelling approach for the leaching and reactive transport of major and trace elements in MSWI bottom ash

Dijkstra, J. J. *et al. Applied Geochemistry*, 2008, 23, (6), 1544–1562.

To improve the long-term environmental risk assessment of waste applications, a predictive 'multi-surface' modelling approach has been developed to simultaneously predict the leaching and reactive transport of a broad range of major and trace elements (i.e. pH, Na, Al, Fe, Ca, SO_4, Mg, Si, PO_4, CO_3, Cl, Ni, Cu, Zn, Cd, Pb, Mo) and fulvic acids from MSWI bottom ash. The geochemical part of the model approach incorporates surface complexation/precipitation on Fe/Al (hydr)oxides, complexation with humic and fulvic acids (HA and FA, respectively) and mineral dissolution/precipitation. In addition, a novel approach is used to describe the dynamic leaching of FA, based on the surface complexation of FA on Fe/Al (hydr)oxides. To enable reactive transport calculations, the geochemical part of the model is combined with advective/dispersive transport of water and first-order mass transfer between mobile and stagnant zones. Using a single, independently determined set of input parameters, adequate model predictions are obtained for the leaching of a broad range of elements under widely different conditions, as verified with data from the European standardized pH-static and percolation leaching tests (TS 14997 and TS 14405, respectively). The percolation tests were operated at different flow velocities and with flow interruptions to enable verification of the local equilibrium assumption. Although the combination of experimental and modelling results indicates that the leaching of major solubility-controlled elements occurs largely under local equilibrium conditions, this study has led to the identification of physical non-equilibrium processes for non-reactive soluble salts, as well as possible sorption-related non-equilibrium processes for the leaching of Mo, FA and associated trace metals. Further improvement of the reactive transport model can be achieved by a more mechanistic description of the (dynamic) leaching behaviour of humic substances. As the modelling approach outlined in this study is based on the fundamental processes that underlie leaching, the approach is expected to be also applicable to other granular contaminated materials application scenarios and conditions. Therefore, the combination of standardized leaching test methods, selective chemical extractions and mechanistic modelling, constitutes a promising generic approach to assess the long-term environmental impact of the application of granular contaminated materials in the environment.

08/02653 Agglomeration in fluidized beds at high temperatures: mechanisms, detection and prevention

Bartels, M. *et al. Progress in Energy and Combustion Science*, 2008, 34, (5), 633–666.

Fluidized-bed conversion of solid fuels is a well-established and widely used technology. Yet, operational problems are encountered in industrial practice. One of the most important problems is the occurrence of agglomeration at high temperature, meaning that bed particles adhere to each other to form larger entities (agglomerates). This process is often not recognized until sudden defluidization and often leads to a costly shutdown of the whole installation. In particular, the thermal conversion of certain biomass fuels, which is becoming increasingly popular, increases the risk of agglomeration. This paper critically reviews the current research status of this topic in terms of agglomeration mechanisms, detection and counteraction strategies. To understand the complex phenomenon of agglomeration in fluidized beds at high temperatures different areas are distinguished viz. hydrodynamics, chemical reaction mechanisms, particle interaction mechanisms and molecular cramming. Special emphasis is given to the detection of agglomeration. The range of detection methods is comprised of fuel ash analysis methods to predict potential agglomeration as well as analysis methods based on (on-line) process measurements, such as pressure and temperature. Finally, different methods to counteract agglomeration phenomena are presented; they comprise operational measures, utilization of additives, alternative bed materials and improved reactor design.

08/02654 Alternative trends in development of thermal power plants

Prisyazhniuk, V. A. *Applied Thermal Engineering*, 2008, 28, (2–3), 190–194.

Thermal (or fossil fuel) power plants (TPP) are the major polluters of man's environment, discharging into the atmosphere the basic product of carbon fuel combustion, carbon dioxide. It is this very gas that accounts for the greenhouse effect causing the global climate warm-up on the planet. A natural solution of the problem of reducing carbon dioxide discharge into the atmosphere lies in power saving, thus reducing the amount of the fuel burnt. This approach can be justified from any standpoint, both economically and ecologically. The ideal way of solving the problem would be to completely give up burning carbon-containing fuel, such as coal, petroleum products, and other power resources of organic nature. This work is intended to outline the ways of reducing consumption of fuel by TPP and, consequently, of reducing their discharging into the atmosphere the gases producing the greenhouse effect. One of the ways lies in changing the thermophysical characteristics of the working medium, which becomes possible if the authors can modify the conventional working medium, that is water, or can use some working medium with quite different thermophysical properties. The article dwells on various technological ways providing for a practical solution of the problem, such as the Kalina cycle; modification of water properties by way of magneto-hydrodynamic resonance; and employing, in the thermodynamic cycle of thermal power plants, liquids boiling at temperatures which are lower than that of the environment.

08/02655 CFD based evaluation of heat transfer coefficient from cylindrical particles

Ahmadi Motlagh, A. H. and Hashemabadi, S. H. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 674–680.

Two- and three-dimensional computational fluid dynamics (CFD) modelling of heat transfer from discrete circular cylindrical particles in four different situations including (A) infinite cylinder in cross-flow, (B) cross-flow on finite cylinder with different aspect ratio in a rectangular duct, (C) axial-flow on finite cylinder, and (D) axial-flow on finite cylinder with upstream turbulence have been investigated with the commercial CFD software, FEMLAB. The results were validated using experimental data from different research papers and also experimental correlations and show good quantitative and qualitative agreement with each other. In case B, a correction term has been proposed from CFD work which is applied to an experimental correlation to consider the aspect ratio influence on predicting the Nusselt number with an average error of 3.7%.

08/02656 Characterization of fly ash from a power plant and surroundings by micro-Raman spectroscopy

Guedes, A. *et al. International Journal of Coal Geology*, 2008, 73, (3–4), 359–370.

Fly ash samples were collected from a Portuguese power plant that burns low-sulfur coals from South Africa, USA, Colombia, and Australia. The fly ashes were collected from the hoppers of the economizers, air heaters, electrostatic precipitators, and from the stack. The power plant air monitoring system was also sampled. The fly ash characterization was conducted by micro-Raman spectroscopy. The micro-Raman spectroscopic analysis permitted an efficient identification and characterization of different inorganic and organic materials present in fly ash: quartz, hematite, magnetite, calcite, glass, aluminium and calcium oxides, and different types of organic constituents. The study of the structural evolution of the unburned carbon/char material during their path through the power plant, though the use of Raman spectra and Raman parameters reveal that despite the high temperatures they reached, these materials are still structurally disordered. However, a structural evolution occurs in the char from the economizer up to the electrostatic precipitators where the char is structurally more disordered. The different features of the Raman spectra observed for carbon particles collected from the stack, together with the high range of variation of the Raman parameters, confirm the existence of different carbon particles in the stack, i.e. char and others (probably soot). The filters from the surroundings contain a variety of carbon particles with Raman parameters different from the ones obtained in the fly ash hoppers and stack. These are diesel particles as indicated by the values of W_{D1}, $FWHM_{D1}$, $FWHM_G$, W_G and ID1/IG obtained.

08/02657 Coal combustion modelling of large power plant, for NO_x abatement

Le Bris, T. *et al. Fuel*, 2007, 86, (14), 2213–2220.

This paper presents the comparison of experimental results and computational fluid dynamics (CFD) simulations for a 600 MWe industrial pulverized coal power station. The power station measurements were made in a normal combustion mode and in an overfire air (OFA) mode. The agreement between the model and the data collected in the chimney is good; the NO_x reduction modelled is in agreement with the measured one, but data taken in the flame show that the flame structure is imperfectly represented.

08/02658 Comparison of modelling approaches and layouts for solar chimney turbines

Fluri, T. P. *et al. Solar Energy*, 2008, 82, (3), 239–246.

The turbogenerator is a core component of any solar chimney power plant. Various layouts for the turbogenerator have been proposed in the literature. In this paper the performance of these layouts is compared using analytical models and optimization techniques, and the important design parameters are discussed. The turbine layouts under consideration are single rotor and counter rotating turbines, both with or without inlet guide vanes. In contrast to similar investigations found in the literature, various radial sections along the blades are analysed in the turbine model. This approach is more appropriate than using a simple mean line analysis when dealing with turbines with high blade aspect ratio and low hub to tip ratio. Furthermore, a limit to the degree of reaction of the turbine has been introduced to avoid diffusion at the hub. It is shown in this paper that these slight changes in modelling approach have a significant impact on the performance prediction. Further it can be concluded that the single rotor layout without guide vanes performs very poorly; the efficiency of the other three layouts is much better and lies in a narrow band. The counter rotating layouts provide the highest peak efficiencies, but at relatively low speeds, which leads to an undesirable higher torque for the same power output.

08/02659 Computational fluid dynamics (CFD) simulation of flow in the rotary drum for pyrite bio-preoxidization

Liu, T. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 971–978.

A two-dimensional algebric slip mixture computational fluid dynamics (CFD) model was developed to simulate the flow and mixing of liquid–gas-particle system in a rotary drum. The simulations show that there are several flow regimes in slurry phase, including anti-clockwise circulation flow of liquid, rising stream of bubbles, circumferential flow and eddy. The gas disperses mainly in a limited area in the vertical region of bubble stream. Pyrite particle mixing is mainly arised from the movement of baffles, and the distribution of particles is well. The increase of aeration rates would give rise to an increase of the volumetric averaged gas holdup. The increase of rotation speed has little influence in the averaged gas holdup. When three gas spargers were molded in the drum, there is not obvious improvement of gas holdup and particle mixing.

08/02660 Computational fluid dynamics of a circulating fluidized bed under various fluidization conditions

Almuttahar, A. *et al.* Taghipour, Z. *Chemical Engineering Science*, 2008, 63, (6), 1696–1709.

A computational fluid dynamics (CFD) model was developed to simulate the hydrodynamics of gas–solid flow in a circulating fluidized bed (CFB) riser at various fluidization conditions using the Eulerian–Granular multiphase model. The model was evaluated comprehensively by comparing its predictions with experimental results reported for a CFB riser operating at various solid mass fluxes and superficial gas velocities. The model was capable of predicting the main features of the complex gas–solids flow, including the cluster formation of the solid phase along the walls, for different operating conditions. The model also predicted the coexistence of up-flow in the lower regions and downward flow in the upper regions at the wall of the riser for high gas velocity and solid mass flux, as reported in the literature. The predicted solid volume fraction and axial particle velocity were in good agreement with the experimental data within the high density fast fluidization regime. However, the model showed some discrepancy in predicting the gas–solid flow behaviour in the riser operating in dense suspension up-flow and low density fast fluidization regimes.

08/02661 Continuous monitoring of CO_2 yields from electrochemical oxidation of ethanol: catalyst, current density and temperature effects

Ghumman, A. *et al. Journal of Power Sources*, 2008, 177, (1), 71–76.

A very simple method for continuous quantification of carbon dioxide yields from electrochemical processes, using a commercial carbon dioxide detector, is presented. Application of this method to electrochemical oxidation of ethanol greatly decreases the time needed to evaluate catalyst behaviours and allows for efficient elucidation of the factors that influence carbon dioxide yields. A systematic study of the effects of current density and temperature on the performances of Pt and PtRu anode catalysts has been carried out. The amount of carbon dioxide produced at each current and temperature has been measured in real time. Yields of carbon dioxide, the product of total oxidation of ethanol, are compared with the limited results reported in the literature for direct ethanol fuel cells.

08/02662 Control of the fluidised bed in the pellet softening process

van Schagen, K. *et al. Chemical Engineering Science*, 2008, 63, (5), 1390–1400.

Multiple fluidized bed reactors for water softening (crystallization of calcium carbonate) have been in operation at drinking water treatment plants since the late 1980s. Research on the operation of these pellet reactors has been focused on investigating crystallization under constant fluidized bed composition. However, in practice the bed composition varies frequently, despite large effort of plant operators. An improvement in the control of the fluidized bed can be achieved by using model-based multivariable control. Due to the non-linear behaviour of the reactor, caused by water temperature variation during the year, a non-linear control approach is used. A particle filter, based on a first-principles model, estimates the state of the softening reactor and a non-linear model-predictive controller determines the values of the manipulated variables. In a simulation experiment, it is shown that it is possible to keep the reactor at desired operational parameters (pellet size and bed height) under varying operational conditions. In this way, the cost of pellet softening can be reduced and irregularities prevented.

08/02663 Effect of rounding of protruding edge on convection heat transfer in a converging–diverging channel

Islamoglu, Y. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 643–647.

Experiments were performed to determine convection heat transfer characteristics for the rounding of the protruding peaks of a corrugated channel. Results were carried out for a Prandtl number of 0.7 in the Reynolds number range from 2000 to 5000 for the corrugation angle of 30° and channel height of 5 mm. In order to determine the channel having the best performance, the channels were also compared by considering the flow area goodness factor. The heat transfer performance for the channel with rounded corrugation peak is greater than that for the sharp peak about 100%.

08/02664 Eulerian simulation of heterogeneous gas–solid flows in CFB risers: EMMS-based sub-grid scale model with a revised cluster description

Wang, J. *et al. Chemical Engineering Science*, 2008, 63, (6), 1553–1571.

Gas–solid two-phase flow in CFB risers is characterized by the clustering of solid particles producing dynamical multi-scale structures, and how to quantify such heterogeneity is a critical yet unsolved issue. Recently, incorporating the energy minimization multi-scale (EMMS) model with Eulerian approach has obtained encouraging results for simulating the hydrodynamics in CFB risers. However, owing to the cluster diameter correlation used, the present model is still limited to the simulation of Geldart A particles. In this study, a stochastic geometry approach named doubly stochastic Poisson processes is used to analyse the fluctuation characteristics of solid concentration in CFB risers, which provides a mean to define the solid concentration inside clusters. The predicted results are validated by experimental data available in literature, and a revised cluster diameter correlation is then proposed for EMMS model previously developed for cocurrent-up gas–solid flow. Following the previous studies, the EMMS model thus improved is incorporated into an Eulerian–Eulerian description of gas–solid flow as a sub-grid scale model for inter-phase drag force, with which the hydrodynamics of both Geldart A and Geldart B particles in CFB risers are simulated. It is shown that the experimentally found S-shaped axial voidage profiles and the choking phenomenon can be well predicted. The computed one-dimensional slip velocities decrease toward the top of the risers and increase with decreasing cross-sectional averaged voidages. The experimentally found dependence of the root mean square of the solid concentration on its mean value at a given position is also well predicted.

08/02665 Evaluation of energy requirements in membrane distillation

Criscuoli, A. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (7), 1098–1105.

This paper presents a study of energy requirements of membrane distillation (MD) for different lab-made flat module designs of 40 cm^2 membrane area. The MD runs were carried out in direct contact membrane distillation (DCMD) and vacuum membrane distillation (VMD) mode with a 0.2 µm polypropylene membrane and in all tests pure water was fed to the system. In DCMD, the effect of the operating temperatures and streams flow rates on the flux, the evaporation efficiency and the energy consumption, was studied, whereas in VMD the parameters analysed were the feed flow rate, the feed temperature and the vacuum applied at the permeate side. The VMD performed better than the DCMD and the cross-flow module resulted to be the most efficient design for obtaining high fluxes with moderate energy consumptions. The highest flux (56.2 $\text{kg/m}^2\,\text{h}$) was achieved with the cross-flow module working in VMD at a feed flow rate of 235 L/h, feed temperature of 59.2 °C and a permeate pressure of 10 mbar. The lowest values of energy consumption/permeate flow rate ratios obtained were 3.55 $\text{kW/(kg h}^{-1})$ (longitudinal-flow membrane module) and 1.1 $\text{kW/(kg h}^{-1})$ (cross-flow membrane module) for DCMD and VMD tests, respectively.

08/02666 Further investigation on the performance of a shower cooling tower

Qi, X. and Liu, Z. *Energy Conversion and Management*, 2008, 49, (4), 570–577.

This study was prompted by the need to design towers for applications in which, due to salt deposition on the packing and subsequent blockage, the use of tower packing is not practical. In the previous model the authors presented, three critical assumptions were made to reduce the complexity and computational time, which can also reduce the models' accuracy. Accurate modelling of the operating process is a determining factor both for designing the shower cooling tower (SCT) and for optimizing its operation. In this paper, a new model is derived without applying the three assumptions. According to the condition of the outlet air, the governing equations consider two cases, including the supersaturated and unsaturated states. This model is used to predict the performance of a full scale SCT located in China with different conditions for validation. The differences in the heat and mass transfer analyses of the two models are described at different atmospheric conditions.

08/02667 Heat source and radiation effects on magneto-convection flow of a viscoelastic fluid past a stretching sheet: analysis with Kummer's functions

Singh, A. K. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 637–642.

An analysis was carried out to study heat source and radiation effects on the two-dimensional steady flow of an electrically conducting, incompressible, viscoelastic fluid (Walter's liquid-B) past a stretching sheet in the presence of transverse uniform magnetic field. Two cases were studied: (i) the sheet with prescribed power law surface temperature (PST case) and (ii) the sheet with prescribed power law surface heat flux (PHF case). Kummer's functions are used to obtain temperature field and wall temperature gradient. The variations in the velocity and temperature field with change in parameters encountered into the equations were obtained and depicted graphically. The numerical values of the variations in wall temperature gradient due to change in physical parameters are presented in the tables.

08/02668 Integration of distributed generation systems into generic types of commercial buildings in California

Medrano, M. *et al. Energy and Buildings*, 2008, 40, (4), 537–548.

Distributed generation (DG) of combined cooling, heat, and power (CCHP) has been gaining momentum in recent years as an efficient, secure alternative for meeting increasing power demands in the world. One of the most critical and emerging markets for DG-CCHP systems is commercial and institutional buildings. The present study focuses analysis on the main economic, energy-efficiency, and environmental impacts of the integration of three types of advanced DG technologies (high-temperature fuel cells, micro-turbines, and photovoltaic solar panels) into four types of representative generic commercial building templates (small office building, medium office building, hospital, and college/school) in southern California (e.g. mild climate), using eQUEST as energy simulation tool. Detailed load profiles for the four commercial building types during times of peak electric and peak gas consumption were analysed and complementary strategies to further increase overall building energy efficiencies such as energy efficiency measures (e.g. day lighting, exterior shading, improved HVAC performance) and thermally activated absorption cooling were also investigated. Results show that the high-temperature fuel cell (HTFC) performance is best matched with the hospital energy loads, resulting in a 98% DG capacity factor, 85% DG heat recovery factor, and $860,000 in energy savings (6 years payback). The introduction of thermally driven double-effect absorption cooling in the college building with HTFC reduces significantly the building electricity-to-thermal load ratio and boosts the heat recovery factor from 37% to 97%.

08/02669 Modelling and simulation of a gas–solids dispersion flow in a high-flux circulating fluidized bed (HFCFB) riser

Bastos, J. C. S. C. *et al. Catalysis Today*, 2008, 130, (2–4), 462–470.

Radial solids velocity profiles were computed on seven axial levels in the riser of a high-flux circulating fluidized bed (HFCFB) using a two-phase three-dimensional computational fluid dynamics model. The computed solids velocities were compared with experimental data on a riser with an internal diameter of 76 mm and a height of 10 m, at a high solids flux of 300 $\text{kg m}^{-2}\,\text{s}^{-1}$ and a superficial velocity of 8 m s^{-1}. Several hundreds of experimental and numerical studies on CFBs have been carried out at low fluxes of less than 200 $\text{kg m}^{-2}\,\text{s}^{-1}$, whereas only a few limited useful studies have dealt with high solids flux. The k–ε two-phase turbulence model was used to describe the gas–solids flow in an HFCFB. The model predicts a core–annulus flow in the dilute and developed flow regions similar to that found experimentally, but in the region of highest solids concentration it is somewhat overpredicted at the level close to the inlet.

08/02670 Nonlinear torque and stator flux controller for induction motor drive based on adaptive input–output feedback linearization and sliding mode control

Yazdanpanah, R. *et al. Energy Conversion and Management*, 2008, 49, (4), 541–550.

This paper describes a non-linear torque and stator flux controller for three phase induction motor (IM) drives on the basis of a space vector modulation (SVM) scheme. Using the IM fifth-order model in a fixed 'ab' axis reference frame with stator currents (i_{sa}, i_{sb}) and stator fluxes (Ψ_{sa},Ψ_{sb}) as state variables, a sliding mode (SM) torque and flux controller is designed first in order to track a linear reference model, which has the desired dynamic behaviours for the IM drive system. The SM controller generates the reference voltages (υ_{as}^{+}, υ_{bs}^{+}) for a two level space vector modulation-pulse width modulation (SVM–PWM) inverter that feeds the motor. Then, the SM controller is combined with an adaptive input–output feedback linearization technique in order to preserve the system robustness with respect to stator and rotor resistances variations and uncertainties. Finally, simulations and comparative experimental results with the proposed control scheme are presented.

08/02671 Optimisation of membrane area and energy requirement in tubular membrane modules

Nordin, A.-K. and Jönsson, A.-S. *Chemical Engineering and Processing: Process Intensification*, 2008, 47, (7), 1090–1097.

During ultrafiltration (UF), the driving force along the membrane is diminished due to concentration increase and frictional pressure drop. In most applications of ultrafiltration the influence of the frictional pressure drop is negligible. However, when treating concentrated, viscous liquids the frictional pressure drop can reduce the transmembrane pressure significantly. The influence of cross-flow velocity and inlet pressure on flux and frictional pressure drop during concentration of retentate from the Stora Enso Nymölla pulp and paper mill ultrafiltration plant treating hardwood bleach plant effluent was studied in this work. The experimental data were used in a calculation tool to investigate the membrane area and energy requirement of two module design alternatives during concentration of the retentate in an additional stage. The first alternative is the same module design as in the existing plant on the hardwood line at Nymölla, where the tubular membranes in a module are connected in series. In the second alternative, the membrane tubes in a module were instead connected in parallel. The experimental flux increased markedly with increasing pressure and cross-flow velocity at all concentrations. However, the flux was significantly reduced when the chemical oxygen demand was increased. The flux was 120 l/m^2 h at 180 g/l and 23 l/m^2 h at 330 g/l (at 1.0 MPa and 4 m/s). The concentration was 180 and 330 g/l at volume reduction factor (VRF) 1 and 2. The calculated average flux was significantly higher in the design with membrane tubes in parallel. In addition, the flux was not only higher, but it also increased with increasing cross-flow velocity, whereas the flux in the design with membrane tubes in series reached a maximum flux at about 3 m/s.

08/02672 Optimum gas turbine cycle for combined cycle power plant

Polyzakis, A. L. *et al. Energy Conversion and Management*, 2008, 49, (4), 551–563.

The gas turbine based power plant is characterized by its relatively low capital cost compared with the steam power plant. It has environmental advantages and short construction lead time. However, conventional industrial engines have lower efficiencies, especially at part load. One of the technologies adopted nowadays for efficiency improvement is the ‘combined cycle’. The combined cycle technology is now well established and offers superior efficiency to any of the competing gas turbine based systems that are likely to be available in the medium term for large-scale power generation applications. This paper has as objective the optimization of a combined cycle power plant describing and comparing four different gas turbine cycles: simple cycle, intercooled cycle, reheated cycle and intercooled and reheated cycle. The proposed combined cycle plant would produce 300 MW of power (200 MW from the gas turbine and 100 MW from the steam turbine). The results showed that the reheated gas turbine is the most desirable overall, mainly because of its high turbine exhaust gas temperature and resulting high thermal efficiency of the bottoming steam cycle. The optimal gas turbine cycle will lead to a more efficient combined cycle power plant, and this will result in great savings. The initial approach adopted is to investigate independently the four theoretically possible configurations of the gas plant. On the basis of combining these with a single pressure Rankine cycle, the optimum gas scheme is found. Once the gas turbine is selected, the next step is to investigate the impact of the steam cycle design and parameters on the overall performance of the plant, in order to choose the combined cycle offering the best fit with the objectives of the work as depicted above. Each alterative cycle was studied, aiming to find the best option from the standpoint of overall efficiency, installation and operational costs, maintainability and reliability for a combined power plant working in base load. Several schemes are proposed for investigation. In particular, four configurations were studied: simple cycle, intercooled cycle, reheated cycle and intercooled and reheated cycle.

08/02673 Reverse osmosis alternative: energy implication for sugar industry

Madaeni, S. S. and Zereshki, S. *Chemical Engineering and Processing: Process Intensification*, 2008, 47, (7), 1075–1080.

In classical sugar factories, evaporation is one of the most energy intensive unit operations which mainly used for concentrating thin sugar juice. Replacing or combining this process with low energy consuming processes such as membranes could save large amounts of energy. There is no phase change in common membrane technologies and therefore they are low energy consumers. In the present study, a two-stage reverse osmosis system was investigated for pre-concentrating the sugar syrup. The energy consumption was compared for conventional evaporation versus reverse osmosis combined with evaporation. The obtained results represented several benefits such as significant energy saving and no thermal loss of sugar using the reverse osmosis system.

08/02674 Techno-economic evaluation of a PVAm CO_2-selective membrane in an IGCC power plant with CO_2 capture

Grainger, D. and Hägg, M.-B. *Fuel*, 2008, 87, (1), 14–24.

Published data for an operating power plant, the ELCOGAS 315 MWe Puertollano plant, has been used as a basis for the simulation of an integrated gasification combined cycle process with CO_2 capture. This incorporated a fixed site carrier polyvinylamine membrane to separate the CO_2 from a CO-shifted syngas stream. It appears that the modified process, using a sour shift catalyst prior to sulfur removal, could achieve greater than 85% CO_2 recovery at 95 vol% purity. The efficiency penalty for such a process would be approximately 10% points, including CO_2 compression. A modified plant with CO_2 capture and compression was calculated to cost €2320/kW, producing electricity at a cost of 7.6 € cents/kWh and a CO_2 avoidance cost of about €40/tonne CO_2.

08/02675 The energy efficiency paradox revisited through a partial observability approach

Kounetas, K. and Tsekouras, K. *Energy Economics*, 2008, 30, (5), 2517–2536.

The present paper examines the energy efficiency paradox demonstrated in Greek manufacturing firms through a partial observability approach. The data set used has resulted from a survey carried out among 161 energy-saving technology firm adopters. Maximum likelihood estimates that arise from an incidental truncation model reveal that the adoption of the energy-saving technologies is indeed strongly correlated to the returns of assets that are required in order to undertake the corresponding investments. The source of the energy efficiency paradox lies within a wide range of factors. Policy schemes that aim to increase the adoption rate of energy-saving technologies within the field of manufacturing are significantly affected by differences in the size of firms. Finally, mixed policies seem to be more effective than policies that are only capital subsidy or regulation oriented.

08/02676 The generation of microwave-induced plasma in granular active carbons under fluidised bed conditions

Dawson, E. A. *et al. Carbon*, 2008, 46, (2), 220–228.

Some of the phenomena associated with the interaction of microwave (MW) radiation with a granular activated carbons fluidised bed were studied in a single mode microwave apparatus. The sample heating section incorporated ports for a light measurement device (light dependent resistor, LDR) and camera, and a fluoroptic probe was used for sample temperature measurement. During fluidization under various MW power regimes, the discharge activity and plasma generation within the carbon bed were quantified using the LDR and images captured. The MW dielectric heating of the carbons was measured with the fluoroptic probe and its relation to the fundamental dielectric parameter, the loss factor, ε'', studied. Factors found to affect the MW heating and plasma generation within the fluidized carbon were the thermal history of the sample and presence of trace amounts of metals, especially potassium. These factors influenced the degree to which a tendency to thermal runaway was observed during MW plasma generation.

08/02677 The local heat transfer mathematical model between vibrated fluidized beds and horizontal tubes

Zhu, X. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (6), 1279–1286.

A dimensionless mathematical model is proposed to predict the local heat transfer coefficients between vibrated fluidized beds and immersed horizontal tubes, and the effects of the thickness of gas film and the contact time of particle packets are well considered. Experiments using the glass beads (the average diameter $d_p = 1.83$ mm) were conducted in a two-dimensional vibrated fluidized bed (240 mm × 80 mm). The local heat transfer law between vibrated fluidized bed and horizontal tube surface has been investigated. The results show that the values of theoretical prediction are in good agreement with experimental data, so the model is able to predict the local heat transfer coefficients between vibrated fluidized beds and immersed horizontal tubes reasonably well, and the error is in range of ±15%. The results can provide references for future designing and researching on the vibrated fluidized beds with immersed horizontal tubes.

10 SPACE HEATING AND COOLING/HEAT PUMPS

08/02678 A comparative study on the performance and environmental characteristics of R410A and R22 residential air conditioners

Chen, W. *Applied Thermal Engineering*, 2008, 28, (1), 1–7.

R410A is a long-term alternative refrigerant with zero ODP (ozone-depleting-potential) for replacing R22. In this paper, four sets of comparable R410A and R22 split-type residential air conditioners (A/C) were developed and then their performance was comparatively studied using one simulation software. The A/C performance compared in this paper included the cooling capacity, EER (energy efficiency ratio), annual power consumption of A/C and the global warming impact of refrigerants adopted by the A/C. It was concluded that the adoption of R410A could be helpful for A/C to decrease their heat exchanger size or improve their operation efficiency for power saving. Moreover, compared to R22, R410A could in fact help alleviate its overall impact on global warming through significantly reducing the indirect global warming impact caused by operating R410A A/C.

08/02679 A methodology to select the experimental plant instrumentation based on an a priori analysis of measurement errors and instrumentation cost

Mastrullo, R. *et al. International Communications in Heat and Mass*, 2008, 35, (6), 689–695.

An experimental apparatus for evaluating carbon dioxide local heat transfer coefficients during flow boiling has been set up at University of Naples Federico II. In this paper, the local heat transfer coefficient measured is evaluated relative to the measurement error, varying the type and costs of the instrumentation. The analytical analysis has been performed prior to construction of the test facility. The main aim of the work is to provide a methodology that allows one to reach the best compromise between measurement accuracy and financial resources in the selection of the instrumentation.

08/02680 A new control algorithm for direct expansion air conditioning systems for improved indoor humidity control and energy efficiency

Xu, X. *et al. Energy Conversion and Management*, 2008, 49, (4), 578–586.

This paper presents an experimental study to develop a new control algorithm to replace the traditional on–off control algorithm widely used by direct expansion (DX) air conditioning (A/C) systems, which are widely used in small to medium sized buildings. The new control algorithm, which enables both the compressor and the supply air fan in a DX A/C system to operate at high speeds when the indoor air dry bulb temperature setting is not satisfied and at low speeds otherwise, is termed the H–L control. Extensive experiments have been conducted with an experimental DX A/C system at simulated different climates under both H–L and on–off control. The results suggest that the use of H–L control would result in better control performance in terms of an improved indoor humidity level and a higher energy efficiency of the DX A/C system when compared to the use of the traditional on–off control. The H–L control is also simpler, and its associated hardware cost is much lower than that of the control algorithms based on variable speed technology.

08/02681 A second degree approximation for the calculation of the transfer function coefficients for heat conduction through walls

Chena, Y. C. and Wilson, R. *Energy and Buildings*, 2008, 40, (4), 549–556.

Calculation of the conduction transfer function coefficients using a state space representation requires the transient governing differential equation to be discretized in space by the use of finite difference or finite element methods, in order to obtain a set of first order differential equations. The use of finite element methods to discretize the media gives an additional advantage due to it is possible to use a higher order approximation of the dependent variable, which gives us a better accuracy with less elements. In this paper, the transient heat flow problem is tackled using a quadratic finite element. The variational formulation for the governing differential equation is developed, the Ritz approximation to construct the finite element formulation is used and the approximation functions are presented using a normalized local coordinate system for elements with three equally spaced nodes for the one-dimensional problem. The two-dimensional transient problem is presented using a rectangular eight-node element. Results with 1, 2 and 3 three-node elements are compared with the ASHRAE conduction transfer functions for the 3, 5, 6, 8 and 32 wall groups and a two-dimensional example is given.

08/02682 Application of an integrated indoor climate, HVAC and showcase model for the indoor climate performance of a museum

van Schijndel, A. W. M. *et al. Energy and Buildings*, 2008, 40, (4), 647–653.

This paper presents a case study on the performance-based design of a heating, ventilating and air-conditioning (HVAC) system and controller of a museum. A famous museum in the Netherlands has reported possible damage to important preserved wallpaper fragments. The paper provides an evaluation of the current indoor climate by measurements, showing that the indoor climate performance does not satisfy the requirements for the preservation of old paper. To solve this problem, an integrated heat air and moisture model was developed consisting of models for respectively: the indoor climate, the HVAC system and controller and a showcase. The presented models are validated by a comparison of simulation and measurement results. The integrated model is used for the evaluation of a new HVAC controller design and the use of a showcase. It is concluded that it is not possible to satisfy the indoor climate within the recommended limits, exclusively by the use of a new control strategy. Furthermore in order to meet the recommendations, the wallpaper fragments should be placed in a showcase and a similar control strategy as presented in the paper, has to be implemented in order to limit the room air temperature change.

08/02683 Conjugate conduction–convection analysis of empty freezers

Haldar, S. C. *et al. Energy Conversion and Management*, 2008, 49, (4), 783–790.

This article reports a study on the numerical solution of simultaneous free convection inside empty freezer enclosures with four vertical surfaces as cold isothermal and conduction in the insulation around six faces of the enclosure. The air in the enclosure comes down along the four vertical cold surfaces and rises through a smaller volume away from the vertical walls. The air temperature increases with the distance from the cold surfaces, and at the central region of the freezer, the temperature may be undesirably high, especially for freezers with lower height. Freezers with lower height have a higher average temperature in the storage space and also experiences higher heat loads. Significant temperature variation exists in the vertical direction too, and the upper part of the freezer has a relatively higher temperature.

08/02684 Controlling evaporative thermocapillary convection using external heating: an experimental investigation

Buffone, C. and Sefiane, K. *Experimental Thermal and Fluid Science*, 2008, 32, (6), 1287–1300.

An experimental study has been undertaken to investigate evaporatively driven convection underneath a meniscus (liquid–vapour interface) formed in a vertically oriented capillary tube. The evaporation process is found responsible for inducing a convection pattern in the liquid phase below the meniscus. The convective structure was revealed using a μ-PIV technique. When external heating is applied to the system, the convection pattern is altered and can be reversed depending on the relative position of the heating element with respect to the liquid–vapour interface. An infrared camera was used to measure temperature gradients generated by the heater along the capillary wall and along the liquid–vapour interface. This allowed the investigation of the relation between the temperature gradients generated along the tube wall and the convection taking place in the liquid under the effect of thermocapillary stress thus generated. The present study has demonstrated that the meniscus interfacial temperature profile is key for the onset of thermocapillary convection which is observed experimentally.

08/02685 Convective boiling of pure and mixed refrigerants: an experimental study of the major parameters affecting heat transfer

Greco, A. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 896–909.

An experimental study is carried out to investigate the characteristics of the evaporation heat transfer for different fluids. Namely, pure refrigerants fluids (R22 and R134a), azeotropic and quasi-azeotropic mixtures (R404A, R410A, R507) and zeotropic mixtures (R407C and R417A). The test section is a smooth, horizontal, stainless steel tube (6 mm ID, 6 m length) uniformly heated by the Joule effect. The flow boiling characteristics of the refrigerant fluids are evaluated in 250 different operating conditions. Thus, a data-base of more than 2000 data points is produced. The experimental tests are carried out varying: (i) the refrigerant mass fluxes within the range 200–1100 kg/m^2 s; (ii) the heat fluxes within the range 3.50–47.0 kW/m^2; (iii) the evaporating pressures within the range 3.00–12.0 bar. In this study, the effects on measured heat transfer coefficient of vapour quality, mass flux, saturation temperature, imposed heat flux, thermo-physical properties are examined in detail.

08/02686 Cooling strategy by mixed convection of a discrete heater at its optimum position in a square cavity with ventilation ports

Bilgen, E. and Muftuoglu, A. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 545–550.

In this paper, cooling strategy is studied in a square enclosure with ventilation ports and a discrete heat source at its optimum position. The optimum heater position is searched by maximizing the global conductance at different Rayleigh and Reynolds numbers and considered three different ventilation ports arrangements. The conservation equations of mass, momentum and energy were solved for mixed convection. It was found that the heater position is at off center in all cases, its optimum position is insensitive to the variation of Ra and Re; it solely depends on the ventilation ports arrangement. The Nusselt number is dependent on $Ri = Ra/Re^2$: at its low values, Nu is a decreasing function of Ri and at its high values, it is an increasing function of it.

08/02687 Correlation between the local climate and the free-cooling potential of latent heat storage

Medved, S. and Arkar, C. *Energy and Buildings*, 2008, 40, (4), 429–437.

The natural cooling of energy-efficient buildings using latent heat thermal energy storage (LHTES) that is integrated into the building services makes possible energy savings and improved thermal comfort. In this article, studies of the free-cooling potential for different climatic locations are presented. Six cities from around Europe with a wide range of climatic conditions were selected. The size of the LHTES was optimized on the basis of the calculated cooling degree-hours. First, the influence of the width of the phase change temperature range was analysed and determined the optimal melting temperature of the phase change material (PCM). Then, the optimal LHTES was selected, based on the ratio of the mass of the PCM and the volume flow rate of air ventilating the building. It was found that the optimum PCM has a melting temperature that is approximately equal to the average ambient air temperature in the hottest month, and that the free-cooling potential is proportional to the average daily amplitude of the ambient air's temperature swings. For all the analysed climatic conditions the PCM with a wider phase change temperature range (12 K) was found to be the most efficient. The optimal size of the LHTES for the free cooling of buildings is between 1 and 1.5 kg of PCM per m^3/h of fresh ventilation air.

08/02688 Cryogenic thermal analysis of the HANARO cold neutron moderator cell

Han, G. Y. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 583–588.

Accurate prediction of a temperature distribution is very important for investigating the heat transfer characteristics in a cryogenic system such as a cold neutron moderator cell. The cold neutron moderator cell is a 13.2-cm-diameter cylinder with the liquid hydrogen in it contained by an aluminum alloy cell. It will be placed in a cold neutron hole that is inside the heavy water reflector tank of HANARO. The liquid hydrogen serves both as a neutron moderator and a single-phase cryogenic coolant for the cold neutron moderator cell. For the cold neutron moderator cell, its interactions with neutrons and gamma-rays produce a heat load of 629 W on the aluminum alloy cell and liquid hydrogen itself. A half of the cold neutron moderator cell was modelled with a three-dimensional axisymmetric cylinder geometry by using the HEATING 7.3 code. A numerical analysis was performed to determine the temperature distribution over the entire inner surface of the moderator cell, whose moderator and cell walls are heated differently, under a steady-state operating condition. This paper presents the steady-state temperature distribution for providing the cryogenic thermal analysis and for supporting the thermal stress analysis of the moderator cell walls.

08/02689 Current passage tubes in conductive polymer composite for fluid heating

Glouannec, P. *et al. Energy Conversion and Management*, 2008, 49, (4), 493–505.

This communication reports the design and testing of a tubular heat exchanger in conductive polymer composites using the ohmic effect (current passage tube). The weak inertia and the good thermal efficiencies of such a device are fully suitable for water or thermo-sensitive products heating. The materials of the extruded tubes are obtained by blending an insulating thermoplastic polymer matrix with a conductive filler like carbon black nano particles. The electrical resistivity of the composite can be adjusted by the nature and content of the filler. Consequently, an electrical transformer is no longer needed for the electrical input of the heat exchanger. The results presented deal with two different poly(propylene) tubes. The first one is filled with carbon black only, whereas short carbon fibres are added in the second one. First, the effect of the filler content on the electrical and thermal conductivities is quantified. Then, the coupling of the electrical and thermal phenomena is studied. Experimental tests, performed with and without water flow inside the tubes, were completed on a device developed in the laboratory. These experiments were performed under direct current to show the thermal and electrical behaviours of the tubes. The numerical simulation of the temperature profile in the thickness of the pipes corresponds well with the experimental results.

08/02690 Defrost improvement by heat pump refrigerant charge compensating

Wang, Z. *et al. Applied Energy*, 2008, 85, (11), 1050–1059.

During winters, the air-source heat pump often operates with substantial frost formation on the outdoor heat exchanger, and the frost layer has to be melted away periodically to keep a high heat pump coefficient of performance. Otherwise, the un-melted frost layer and water will become high density frost or ice layer in heating mode. However, it is difficult to melt the frost layer in the defrosting cycle, where the effective defrosting time plays an important role in improving the defrosting ability. Generally, the defrosting time can be decreased by the following ways: increasing the refrigerant flow rate effectively, and rapidly establishing the suction pressure, discharge pressure, and the compressor power. A new heat pump defrost system with a refrigerant charge compensator, instead of the accumulator which is a key component for the frosting cycle performance, is developed in this paper. Furthermore, test results showed that the improved frost system with the compensator worked as expected, and its suction and discharge pressures and the power of the compressor during the defrosting were much larger than before.

08/02691 Design and optimization of multipass heat exchangers

Ponce-Ortega, J. M. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 906–913.

In this paper, a simple algorithm is developed for the design and economic optimization of multiple-pass 1–2 shell-and-tube heat exchangers in series. The design model is formulated using the *FT* design method and inequality constraints that ensure feasible and practical heat exchangers. Simple expressions are obtained for the minimum real (non-integer) number of 1–2 shells in series. A graphical method is also presented to develop some insight into the nature of the optimization problem. The proposed algorithm enables engineers to design optimum multipass heat exchangers quickly and easily. It is also shown how the method can be applied for optimal design of multipass process utility exchangers.

08/02692 Effect of an absorptive coating on solar energy storage in a Thrombe wall system

Nwachukwu, N. P. and Okonkwo, W. I. *Energy and Buildings*, 2008, 40, (3), 371–374.

An analysis is undertaken to show the effects of a range of coating absorptivity values on the improvement of heat transfer across a Thrombe wall (which is used for passive solar heating) and to its enclosure. The analysis shows that enhanced heat delivery to the enclosure of a Thrombe wall system is feasible with the application of an absorptive coating of a superior nature – characterized by high absorptivity and very low emissivity – on the heat-receiving surface of the wall and thus can be seen as a heat transfer enhancement technique.

08/02693 Effect of thermal mass on the thermal performance of various Australian residential constructions systems

Gregory, K. *et al. Energy and Buildings*, 2008, 40, (4), 459–465.

The impact of thermal mass on the thermal performance of several types of Australian residential construction, namely: cavity brick (CB), brick veneer, reverse brick veneer (RBV), and lightweight constructions, was examined numerically using the commercial AccuRate energy rating tool developed by the Australian Commonwealth Scientific and Industrial Research Organization. The performance of each construction type was evaluated using four different hypothetical building envelopes, referred to here as building modules. It was found that the thermal mass had a dramatic impact on the thermal behaviour of the modules studied, particularly in those where the thermal mass was within a protective envelope of insulation. The RBV and CB constructions were found to be the most effective walling systems in this regard.

08/02694 Effects of functional surface on performance of a micro heat pipe

Qu, J. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 523–528.

The effect of a functional surface with the axial ladder contact angle distribution on the thermal performance of a triangular micro heat pipe has been analysed based on a one-dimensional steady-state model. Compared with the traditional micro heat pipe (MHP) with a uniform contact angle distribution on its surface, the simulation results show that a MHP with a functional surface can remove a greater amount of heat under the same condition. The increase in thermal performance is more obvious with the increase in the ladder difference of the contact angles between the adjacent sections of the MHP. The increased thermal performance associated with the functional surface can be attributed to the increase of the liquid capillary force as well as the no obvious increase of the liquid shearing force provided by the functional surface, which also brings about the increase in condensate mass flow rate through the adiabatic section–evaporation section interface. It is also found that for the traditional MHP with uniform contact angle surface, there is an optimal contact angle leading to the maximum heat input. The deviation of the optimal value will decrease the capillary force and thermal performance of the MHP.

08/02695 Experimental and numerical study of mixed convection with flow reversal in coaxial double-duct heat exchangers

Maré, T. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (5), 1096–1104.

Velocity vectors in a vertical coaxial double-duct heat exchanger for parallel ascending flow of water under conditions of laminar mixed convection have been determined experimentally using the particle image velocimetry technique. The measured velocity distributions for large annular flow rates, resulting in an essentially isothermal environment for the stream in the inner tube, are in very good agreement with corresponding numerical predictions. For flow rates of the same order of magnitude in the inner tube and the annulus, and corresponding temperature differences of about 20 °C, experimental observations show that flow reversal occurs simultaneously in both streams over large axial distances for both heating and cooling of the flow in the inner tube.

08/02696 Experimental study of capillary-assisted evaporators

Sabir, H. M. *et al. Energy and Buildings*, 2008, 40, (3), 399–407.

The paper presents the results of experimental work aimed at studying the effect of porous layer parameters on the thermal performance of water evaporators. The results show that there are optimum particle sizes that are associated with maximum boiling heat rates and heat transfer coefficients. The results also show that the layer thickness has monotonic effect on the evaporators' performance but its impact is less pronounced compared to that of the particle size. The trends are explained in terms of the contradicting effects that exist within the layer. The research also showed that the effect of the heat load, represented by temperature and velocity of the load air, was negligible. Boiling heat transfer coefficients of up to 5 kW/m^2 °C were achieved.

08/02697 Extension of heat transfer area using carbon fiber cloths in latent heat thermal energy storage tanks

Nakaso, K. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 879–885.

Carbon fibre cloths are stretched among heat transfer tubes to extend the heat transfer area in latent heat thermal energy storage tanks. The thermal responses of the tanks into which paraffin wax as the thermal energy storage material is packed are experimentally investigated. The experimental results show that the carbon fibre cloths of only 0.4 vol.% improve the heat exchange rate in the tanks. A numerical model describing the heat transfer in the tank well predicts the experimental results. Moreover, the effect of the carbon fibre cloths on the thermal performance for a practical scale tank is numerically discussed.

08/02698 Façades and summer performance of buildings

Eicker, U. *et al. Energy and Buildings*, 2008, 40, (4), 600–611.

External cooling loads of a building façade are caused mainly by shortwave irradiance transmission, but also secondary heat flows from the internal glass panes and through ventilation gains from the façade. In a double façade with sun-blinds in the air gap, thermal energy is produced through absorption on the blinds. The work quantifies the thermal performance of single and double façades under summer conditions using laboratory and full scale building experiments. The experimental results were used for model validation and parameter studies were done using dynamic building simulation tools. While the measured sun-blind surface temperature reached up to 45 °C, the air temperature increase in a one storey high double façade was between 3 and 5 K, with peak values of 8 K. For typical absorption coefficients between 10 and 30% the summer thermal energy produced ranges between 50 and 100 kWh $\mathrm{m}^{-2}_{\text{façade}}$. Depending on the ventilation rates between façade and room, only an air flow fraction of about 10% enters the room and adds to the cooling loads. Additional summer cooling loads through façade ventilation of 2–5 kWh m^{-2} room surface were obtained. The measured total energy transmittance of shaded double façades was about 10%, nearly independent of blind position and opening cross section, so that short wave irradiance can be effectively blocked with sun-blinds. Secondary heat flows only play a role if no shading system is used and are otherwise negligible.

08/02699 Fatty acid/poly(methyl methacrylate) (PMMA) blends as form-stable phase change materials for latent heat thermal energy storage

Alkan, C. and Sari, A. *Solar Energy*, 2008, 82, (2), 118–124.

Fatty acids such as stearic acid (SA), palmitic acid (PA), myristic acid (MA), and lauric acid (LA) are promising phase change materials (PCMs) for latent heat thermal energy storage (LHTES) applications, but high cost is the most drawback which limits the utility area of them in thermal energy storage. The use of fatty acids as form-stable PCM will increase their feasibilities in practical LHTES applications due to reduced cost of the energy storage system. In this regard, a series of fatty acid/poly(methyl methacrylate) (PMMA) blends, SA/PMMA, PA/PMMA, MA/PMMA, and LA/PMMA were prepared as new kinds of form-stable PCMs by encapsulation of fatty acids into PMMA which acts as supporting material. The blends were prepared at different mass fractions of fatty acids (50, 60, 70, 80, and 90% w/w) to reach maximum encapsulation ratio. All blends were subjected to leakage test by heating the blends over the melting temperature of the PCM. The blends that do not allow leakage of melted PCM were identified as form-stable PCMs. The form-stable fatty acid/PMMA (80/20 wt.%) blends were characterized using optic microscopy (OM), viscosimetry, and Fourier transform infrared (FT-IR) spectroscopy methods, and the results showed that the PMMA was compatible with the fatty acids. In addition, thermal characteristics such as melting and freezing temperatures and latent heats of the form-stable PCMs were measured by using differential scanning calorimetry (DSC) technique and indicated that they had good thermal properties. On the basis of all results, it was concluded that form-stable fatty acid/PMMA blends had important potential for some practical LHTES applications such as under floor space heating of buildings and passive solar space heating of buildings by using wallboard, plasterboard or floor impregnated with a form-stable PCM due to their satisfying thermal properties, easily preparing in desired dimensions, direct usability without needing an add encapsulation and eliminating the thermal resistance caused by shell and thus reducing cost of LHTES system.

08/02700 First in situ determination of the thermal performance of a U-pipe borehole heat exchanger, in Cyprus

Florides, G. and Kalogirou, S. *Applied Thermal Engineering*, 2008, 28, (2–3), 157–163.

A ground heat exchanger can be used for the injection or extraction of thermal energy into/from the ground. The line source model is an easy method of evaluating the characteristics of the borehole and does not need expensive equipment. This method is presented and a test is performed in order to determine a borehole's characteristics in layers consisting of clay, silt and sand at various analogies. For the borehole under test the ground thermal conductivity (λ) was found to be 1.605 W/(m K) and the effective borehole thermal resistance (R_b) to be 0.257 K/(W/m). The accuracy of the collected data could be affected mainly by two factors. The first factor is the daily flux penetration through the ground which gradually increases the temperature of the top layers and the second factor is a variation of the heating coil injection rate per active length of borehole. As it was observed this combined effect has a negligible result on the mean fluid temperature during the test hours of 280–400, when the system was operating at steady state. The steady-state conditions yield values of borehole thermal resistance which deviates about 25% from the values given by the line source method. The ground thermal conductivity deviates only about 5%. This method however is not suitable for estimating the above values because of the uncertainty that exists in the estimation of the mean ground temperature, which is not constant throughout the borehole length nor is it constant at different points in a cross section of the grout. Also this method takes a lot of time until the steady state is reached.

08/02701 Flow patterns and thermal comfort in a room with panel, floor and wall heating

Myhren, J. A. and Holmberg, S. *Energy and Buildings*, 2008, 40, (4), 524–536.

Thermal comfort aspects in a room vary with different space heating methods. The main focus in this study was how different heating systems and their position affect the indoor climate in an exhaust-ventilated office under Swedish winter conditions. The heat emitters used were a high and a medium–high temperature radiator, a floor heating system and large wall heating surfaces at low temperature. Computational fluid dynamics (CFD) simulations were used to investigate possible cold draught problems, differences in vertical temperature gradients, air speed levels and energy consumption. Two office rooms with different ventilation systems and heating needs were evaluated. Both systems had high air exchange rates and cold infiltration air. The general conclusions from this study were that low temperature heating systems may improve indoor climate, giving lower air speeds and lower temperature differences in the room than a conventional high temperature radiator system. The disadvantage with low temperature systems is a weakness in counteracting cold down-flow from ventilation supply units. For that reason the location of heat emitters and the design of ventilation systems proved to be of particular importance. Measurements performed in a test chamber were used to validate the results from the CFD simulations.

08/02702 Fluid flow in microtubes with axial conduction including rarefaction and viscous dissipation

Cetin, B. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 535–544.

Graetz problem inside the microtube is revisited considering rarefaction effect, viscous dissipation term and axial conduction in the fluid for uniform wall temperature boundary condition in the slip flow regime. The flow is assumed to be hydrodynamically fully developed, thermally developing, and the velocity profile is solved analytically. The temperature field is determined by the numerical solution of the energy equation. The rarefaction effect is imposed to the problem via velocity-slip and temperature jump boundary conditions. The local and fully developed *Nu* numbers are obtained in terms of dimensionless parameters; *Pe*, *Kn*, *Br*, *?*. Fully developed *Nu* numbers and the thermal entrance length are found to increase by the presence of the finite axial conduction.

08/02703 In situ thermal properties characterization using frequential methods

Carpentier, O. *et al. Energy and Buildings*, 2008, 40, (3), 300–307.

Heat from the soil is widely used for air-conditioning systems in buildings both in Canada and in the Scandinavian countries, and it is spreading. The effectiveness of this technique is based on the soils calorific potential and its thermophysical properties which will define the quality of the exchanges between the soil and a heat transfer fluid. The method to be used for the *in situ* thermophysical characterization of a soil is based upon measuring the heat exchanges on the surface of the soil and on measuring a temperature a few centimetres below the surface. The system is light, inexpensive, well-suited to the taking of measurements *in situ* without the sensors used introducing any disturbance into the heat exchanges. Whereas the majority of methods require excitation, the one presented here is passive and exploits natural signals. Based upon a few hours of recording, the natural signals allow us to identify the soils thermophysical properties continuously. The identification is based upon frequency methods the quality of which can be seen when the thermophysical properties are injected into a model with finite elements by means of a comparison of the temperatures modelled and those actually measured on site.

08/02704 Lighting and cooling energy consumption in an open-plan office using solar film coating

Li, D. H. W. *et al. Energy*, 2008, 33, (8), 1288–1297.

In subtropical Hong Kong, solar heat gain via glazing contributes to a significant proportion of the building envelope cooling load. The principal fenestration design includes eliminating direct sunlight and reducing cooling requirements. Daylighting is an effective approach to allow a flexible building façade design strategy, and to enhance an energy-efficient and green building development. This paper studies the lighting and cooling energy performances for a fully air-conditioned open-plan office when solar control films together with daylight-linked lighting controls are being used. Measurements were undertaken at two stages including the electricity expenditures for the office using photoelectric dimming controls only (first stage) and together with the solar control film coatings on the windows (second stage). Electric lighting and cooling energy consumption, transmitted daylight illuminance and solar radiation were systematically recorded and analysed. The measured data were also used for conducting and validating the building energy simulations. The findings showed that the solar film coatings coupled with lighting dimming controls cut down 21.2% electric lighting and 6.9% cooling energy consumption for the open-plan office.

08/02705 Modeling additional solar constraints on a human being inside a room

Thellier, F. *et al. Solar Energy*, 2008, 82, (4), 290–301.

Sun fluxes induce additional heterogeneous thermal constraints in buildings and may also lead to discomfort for the inhabitant. To calculate the local thermal sensation of a human being totally or partially situated in the sunlight, the solar radiation inside a room and its detailed distribution on parts of the human body are modelled. The present study focuses on the solar gains part of a complete modelling tool simulating an occupied building. The irradiated areas are calculated with a ray tracing method taking shadow into account. Solar fluxes are computed. Fluxes can be absorbed by each surface or reflected. The reflected fluxes are then absorbed at the next impact. A multi-node thermoregulation model (MARCL) represents the thermal behaviour of the human body and all its heat exchanges with the environment. The thermal transient simulation of the whole occupied building is performed in TRNSYS simulation software. In the case presented here, the results show that, when a person is inside the building, the skin and clothing temperatures of the irradiated segments increase more or less depending on the segments but the global thermal equilibrium of the body is maintained thanks to strong physiological reactions.

08/02706 Natural convection heat transfer enhancement in horizontal concentric annuli using nanofluids

Abu-Nada, E. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 657–665.

Heat transfer enhancement in horizontal annuli using nanofluids is investigated. Water-based nanofluid containing various volume fractions of Cu, Ag, Al_2O_3 and TiO_2 nanoparticles is used. The addition of the different types and different volume fractions of nanoparticles were found to have adverse effects on heat transfer characteristics. For high values of Rayleigh number and high L/D ratio, nanoparticles with high thermal conductivity cause significant enhancement of heat transfer characteristics. On the other hand, for intermediate values of Rayleigh number, nanoparticles with low thermal conductivity cause a reduction in heat transfer. For $Ra = 10^3$ and $Ra = 10^5$ the addition of Al_2O_3 nanoparticles improves heat transfer. However, for $Ra = 10^4$, the addition of nanoparticles has a very minor effect on heat transfer characteristics.

08/02707 Numerical and experimental study on heat pump water heater with PCM for thermal storage

Long, J.-Y. and Zhu, D.-S. *Energy and Buildings*, 2008, 40, (4), 666–672.

An air source heat pump water heater with phase change material (PCM) for thermal storage was designed to take advantage of off-peak electrical energy. The heat transfer model of PCM was based upon a pure conduction formulation. Quasi-steady state method was used to calculate the temperature distribution and phase front location of PCM during thermal storage process. Temperature and thermal resistance iteration approach has been developed for the analysis of temperature variation of heat transfer fluid and phase front location of PCM during thermal release process. To test the physical validity of the calculational results, experimental studies about storing heat and releasing heat of PCM were carried. Comparison between the calculational results and the experimental data shows good agreement. Graphical results including system pressure and input power of heat pump, time-wise variation of stored and released thermal energy of PCM were presented and discussed.

08/02708 Numerical modelling of a zeolite/water adsorption cooling system with non-constant condensing pressure

Lu, Y. and Leong, K. C. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 618–622.

A new transient two-dimensional model with non-constant condensing pressure for a zeolite/water adsorption cooling cycle is proposed in this paper. This numerical model focuses on the heat and mass transfer behaviours in the adsorber and is solved by the control volume method. Due to the heat transfer limitation in the condenser, the simulated pressure during the isobaric generation phase of the cycle is not constant and will decrease with time. Compared with the model for constant condensing pressure, the cycle duration and cycled adsorbate for the base case are increased. Furthermore, the effect of mass flow rate of condenser cooling water on system performance is also investigated. It is found that both COP and SCP increase with an increase in the mass flow rate of cooling water in the condenser.

08/02709 Numerical study of three-dimensional turbulent natural convection in a differentially heated air-filled tall cavity

Yang, H. and Zhu, Z. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 606–612.

Correct description of turbulent natural convection plays an important role in the field of heat transfer and building environment. The natural convection in turbulent regime in a tall cavity can exhibit a complex dynamic behaviour that affects the momentum and heat transport between the hot and cold vortical clusters. Using higher order finite difference numerical scheme, the results from this numerical study present the vortical structures in the tall cavity when the height–depth–width ratio is 16:8:1 for higher Rayleigh numbers and the characteristics of the correlation between the velocity components along the horizontal and vertical center lines in the midplane.

08/02710 Optimal linear PI fuzzy controller design of a heat exchanger

Maidi, A. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (5), 938–945.

This study aims at improving the control of a heat exchanger, described by a partial differential equation, by optimizing a linear proportional–integral fuzzy controller. The design of the controller is based on the use of a finite-dimensional approximate model, of high order, derived by spatially lumping the infinite-dimensional model of the heat exchanger. The design procedure consists to optimize the scaling factors of the linear fuzzy controller, by solving an unconstrained optimization problem issued from the simplification of a formulated constrained optimization where the objective function is an integral error measure, and the constraints are the relationships between fuzzy and conventional PID gains. The formulated unconstrained optimization problem is then solved using jointly the Matlab optimization toolbox and Simulink. Through simulation, the performances of the heat exchanger are evaluated, and the obtained results show that the fuzzy controller produces improved control performance with respect to the conventional controller.

08/02711 Optimization of water-cooled chiller system with load-based speed control

Yu, F. W. and Chan, K. T. *Applied Energy*, 2008, 85, 931–950.

This study investigates the energy performance of chiller and cooling tower systems integrated with variable condenser water flow and optimal speed control for tower fans and condenser water pumps. Thermodynamic-behaviour chiller and cooling tower models were developed to assess how different control methods of cooling towers and condenser water pumps influence the trade-off between the chiller power, pump power, fan power and water consumption under various operating conditions. Load-based speed control is introduced for the tower fans and condenser water pumps to achieve optimum system performance. With regard to an example chiller system serving an office building, the optimal control coupled with variable condenser water flow could reduce the annual system electricity use by 5.3% and operating cost by 4.9% relative to the equivalent system using constant speed fans and pumps with a fixed set point for cooling water temperature control.

08/02712 Optimum insulation thicknesses for building walls with respect to cooling and heating degree-hours in the warmest zone of Turkey

Bolattürk, A. *Building and Environment*, 2008, 43, (6), 1055–1064.

Thermal insulation is one of the most effective energy conservation measures for cooling and heating in buildings. Therefore, determining and selecting the optimum thickness of insulation is the main subject of many engineering investigations. In this study, the determination of optimum insulation thickness on external walls of buildings is comparatively analysed based on annual heating and cooling loads. The transmission loads, calculated by using measured long-term meteorological data for selected cities, are fed into an economic model (P_1–P_2 method) in order to determine the optimum insulation thickness. The degree-hours method that is the simplest and most intuitive way of estimating the annual energy consumption of a building is used in this study. The results show that the use of insulation in building walls with respect to cooling degree-hours is more significant for energy savings compared to heating degree-hours in Turkey's warmest zone. The optimum insulation thickness varies between 3.2 and 3.8 cm; the energy savings varies between 8.47 and 12.19 \$/m^2; and the payback period varies between 3.39 and 3.81 years depending on the cooling degree-hours. On the other hand, for heating load, insulation thickness varies between 1.6 and 2.7 cm, energy savings varies between 2.2 and 6.6 \$/m^2, and payback periods vary between 4.15 and 5.47 years.

08/02713 Parametric analysis and optimization for a combined power and refrigeration cycle

Wang, J. *et al. Applied Energy*, 2008, 85, (11), 1071–1085.

A combined power and refrigeration cycle is proposed, which combines the Rankine cycle and the absorption refrigeration cycle. This combined cycle uses a binary ammonia–water mixture as the working fluid and produces both power output and refrigeration output simultaneously with only one heat source. A parametric analysis is conducted to evaluate the effects of thermodynamic parameters on the performance of the combined cycle. It is shown that heat source temperature, environment temperature, refrigeration temperature, turbine inlet pressure, turbine inlet temperature, and basic solution ammonia concentration have significant effects on the net power output, refrigeration output and exergy efficiency of the combined cycle. A parameter optimization is achieved by means of genetic algorithm to reach the maximum exergy efficiency. The optimized exergy efficiency is 43.06% under the given condition.

08/02714 Passive cooling of cement-based roofs in tropical climates

Alvarado, J. L. and Martínez, E. *Energy and Buildings*, 2008, 40, (3), 358–364.

In tropical climates, dwellings are made of cement-based materials like concrete to be able to withstand tropical storms and severe weather conditions. However, cement-based materials exhibit undesirable thermal properties including low thermal conductivity and thermal diffusivity which make living conditions almost unbearable. The purpose of this research project was to investigate the impact of a newly designed passive cooling system which can minimize heat transfer through concrete roofs. The passive cooling system consists of a corrugated aluminum sheet with a unique orientation to promote heat dissipation. A layer polyurethane is also used to minimize heat transfer. Experimental results based on lab-scale prototypes show that the well-designed roof insulation system can reduce the typical thermal load by over 70%. The passive cooling system also shows a desirable slow response time to irradiation, which is a desirable characteristic necessary to effectively control thermal fluctuations and reduce thermal loads simultaneously. The results also indicate that the cement-based roof midpoint temperature can be modelled accurately using an appropriate empirical model.

08/02715 Performance evaluation of standing column well for potential application of ground source heat pump in Jordan

Al-Sarkhi, A. *et al. Energy Conversion and Management*, 2008, 49, (4), 863–872.

Numerical simulation of the heat and fluid flows for the standing column well (SCW) and porous medium around the borehole of the ground source heat pump has been investigated. The finite difference technique was used. Parametric study for several variables has been developed. For example, different bleed ratios of 0.10, 0.20 and 0.30 and far-away temperatures ranging from 15 °C to 60 °C were investigated. An increase in bleed ratio and the far-away temperature will increase the outlet water temperature from the SCW, retuning back to the heat pump. The effect of porosity, ranging from 0.05 to 0.275, was also considered. Increasing porosity decreases the water outlet temperature. Similarly, the effects of Nusselt and Reynolds numbers in the ranges of 15–500 and 1000–11,000, respectively are reported in this paper. Nusselt and Reynolds numbers decrease with the water outlet temperature. The SCW can be employed as a good ground heat exchanger in a geothermal assisted heat pump system. A polynomial correlation of Nusselt number in terms of Reynolds number has been developed.

08/02716 Prediction of refrigerant void fraction in horizontal tubes using probabilistic flow regime maps

Jassim, E. W. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (5), 1141–1155.

A state of the art review of two-phase void fraction models in smooth horizontal tubes is provided and a probabilistic two-phase flow regime map void fraction model is developed for refrigerants under condensation, adiabatic, and evaporation conditions in smooth, horizontal tubes. Time fraction information from a generalized probabilistic two-phase flow map is used to provide a physically based weighting of void fraction models for different flow regimes. The present model and void fraction models in the literature are compared to data from multiple sources including R11, R12, R134a, R22, R410A refrigerants, 4.26–9.58 mm diameter tubes, mass fluxes from 70 to 900 kg/m^2 s, and a full quality range. The present model has a mean absolute deviation of 3.5% when compared to the collected database.

08/02717 Pressure drop optimisation in debottlenecking of heat exchanger networks

Panjeshahi, M. H. and Tahouni, N. *Energy*, 2008, 33, (6), 942–951.

Process integration technology is now widely applied in grass-roots design, energy saving retrofit and the debottlenecking of heat exchanger networks. This technology has been used in a variety of industries and proved to be reliable and applicable in engineering design. Debottlenecking may apply to a specific part or entire unit, whether it is due to increased throughput or process modifications. One of the advanced methods for debottlenecking that is currently used is based upon fixed allowable pressure drops, through which a retrofit can be achieved without a need for pump and/or compressor replacement. This research is trying to develop a new procedure for pressure drop optimization in debottlenecking. This procedure enables the designer to study pump and/or compressor replacement whilst at the same time optimizing the additional area and operating cost of the network. It deals with the problem of optimal debottlenecking of heat exchanger networks considering minimum total cost. Moreover, one can consider the possibility of the replacement of a given pump with a smaller one. The new procedure has been effectively applied to a crude oil pre-heat train, which was subject to some 20% increase in throughput, and the corresponding results proved to be accurate enough.

08/02718 Simulation and optimization of the performance in the air-conditioning season of a BCHP system in China

Cao, J. and Liu, F. *Energy and Buildings*, 2008, 40, (3), 185–192.

Building cooling, heating and power generation (BCHP) is expected to play an important role in the sustainable energy strategy for buildings. However, in many cases the performance of BCHP systems is not as good as predicted and thus perplexes designers and building owners. In this paper the performance of a typical BCHP system is investigated using thermodynamic and thermoeconomic analyses based on the simulation of off-design operation and the performance optimization of the system with the help of a great number of real operation data of the system and the master data supplied by manufacturers. Two optimization problems using exergetic efficiency and gross benefit of the whole BCHP system, respectively, as objective functions are developed in virtue of curve fitting. Computations result in various graphs, which as references are helpful for judging whether or not the system operation is correct. The graphs show that only with enough high load rates can the system operation yield positive benefits. The simulation tells that the fuel cost of BCHP in China accounts for 70–80% of its total cost and therefore is the most important factor in spreading BCHP in the country.

08/02719 Spray cooling heat transfer: technology overview and assessment of future challenges for micro-gravity application

Silk, E. A. *et al. Energy Conversion and Management*, 2008, 49, (3), 453–468.

Advanced on-board flight systems for future NASA space exploration programs consist of components such as laser-diode arrays and multichip modules. Thermal management of these systems require high heat flux cooling capability (≥ 100 W/cm^2), tight temperature control (approx. ±2 °C), reliable start-up (on demand) and long term stability. Traditional multiphase thermal control technologies for space flight (e.g. loop heat pipes, capillary pumped loops, etc.) satisfy the temperature control, start-up and stability requirements, but their heat flux removal capabilities are limited. Spray cooling can provide high heat fluxes in excess of 100 W/cm^2 using fluorinerts and over 1000 W/cm^2 with water while allowing tight temperature control at low coolant fluid flow rates. Spray cooling has been flight proven in an open loop configuration through the Space shuttle's flash evaporator system. However, several closed system issues require investigation to further advance the technology to a technology readiness level appropriate for closed system space flight application. This paper provides a discussion of the current status of spray cooling technology as well as NASA's goals, current direction, and challenges associated with the implementation and practice of this technology in the microgravity environment.

08/02720 Study on preparation of montmorillonite-based composite phase change materials and their applications in thermal storage building materials

Fang, X. *et al. Energy Conversion and Management*, 2008, 49, (4), 718–723.

Three composite phase change materials (PCMs) were prepared by blending butyl stearate, dodecanol and RT20 with an organically modified montmorillonite (MMT), respectively. After the three composite PCMs were characterized by DSC, it was indicated that the RT20/MMT composite PCM was a good candidate for building applications due to its large latent heat, suitable phase change temperature and good performance stability. Compared with RT20, the RT20/MMT composite PCM exhibited higher heat transfer efficiency and had good compatibility with gypsum due to the combination with MMT. The composite gypsum boards containing RT20/MMT composite PCM had the function of reducing building energy consumption by reducing the indoor temperature variation, and the function was enhanced with the increase in the mass ratio of the RT20/MMT composite PCM.

08/02721 The cooling and heating potential of an earth tube system in buildings

Lee, K. H. and Strand, R. K. *Energy and Buildings*, 2008, 40, (4), 486–494.

A new module was developed for and implemented in the EnergyPlus program for the simulation of earth tubes. The module was validated against and showed good agreement with both theoretical and experimental data. Using the new module, a parametric analysis was carried out to investigate the effect of pipe radius, pipe length, air flow rate and pipe depth on the overall performance of the earth tube under various conditions during the cooling season. Pipe length and pipe depth turned out to affect the overall cooling rate of the earth tube, while pipe radius and air flow rate mainly affect earth tube inlet temperature. The cooling and heating potential of earth tubes in four different locations were also investigated. Whether or not an earth tube is beneficial was found to be heavily dependent on the climate of the location in which it was situated.

08/02722 Theoretical performance analysis of heat pump water heaters using carbon dioxide as refrigerant

Laipradit, P. *et al. International Journal of Energy Research*, 2008, 32, (4), 356–366.

The objective of this paper was to simulate the performance of an air source heat pump water heater using carbon dioxide (CO_2) as a working fluid. The heat pump water heating system consisted of a compressor, a gas cooler, an expansion device and an evaporator. The computer simulation model had been developed by using the heat transfer data and the thermodynamic properties of CO_2. The effects on the heat pump performance by the operating parameters such as the compressor rotational speed, the inlet water temperature at the gas cooler, the inlet air temperature at the evaporator and the mass flow rate ratio of water to refrigerant were presented. For rated capacities of a 4 kW compressor with a 10 kW gas cooler and a 6 kW evaporator, the coefficient of performance was found to be between 2.0 and 3.0. The mass flow rate ratio of water and CO_2 between 1.2 and 2.2 was found to be the most suitable value for generating hot water temperature above 60°C at 15–25°C ambient air temperature.

08/02723 Thermal analysis of a building brick containing phase change material

Alawadhi, E. M. *Energy and Buildings*, 2008, 40, (3), 351–357.

This paper presents the thermal analysis of a building brick containing phase change material (PCM) to be used in hot climates. The objective of using the PCM is to utilize its high latent heat of fusion to reduce the heat gain by absorbing the heat in the bricks through the melting process before it reaches the indoor space. The considered model consists of bricks with cylindrical holes filled with PCM. The problem is solved in a two-dimensional space using the finite element method. The thermal effectiveness of the proposed brick-PCM system is evaluated by comparing the heat flux at the indoor surface to a wall without the PCM during typical working hours. A paramedic study is conducted to assess the effect of different design parameters, such as the PCM's quantity, type, and location in the brick. The results indicate that the heat gain is significantly reduced when the PCM is incorporated into the brick, and increasing the quantity of the PCM has a positive effect. PCM cylinders located at the centerline of the bricks shows the best performance.

08/02724 Thermal analysis of slurry ice production system using direct contact heat transfer of carbon dioxide and water mixture

Thongwik, S. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (5–6), 756–761.

This research studies the heat transfer characteristic during ice formation of a direct contact heat transfer between carbon dioxide and water mixture. This research is divided into two parts. For the first part, the low temperature carbon dioxide, between −15 and −60 °C, is injected into water initially at 28 °C and exchanges heat directly. The flow rate of carbon dioxide is varied between 0.003 and 0.017 kg/s while the volume of water is between 1 and 3 L. From the experiment, it is found that the effectiveness of the direct contact heat transfer between the carbon dioxide and the water is closed to 100%. Moreover, the lumped model is found to be used for predicting the temperature of water and the mass of ice formation quite well. However, for this technique, the blockage of ice around the injector always occurs. To avoid this problem, slurry ice is considered instead of pure ice. In the second part of this work, the thermal behaviour of the slurry ice by direct contact heat transfer technique between carbon dioxide and water mixture is investigated. Compressor oil and Tween 60 are mixed with water for making slurry ice and it is found that the suitable composition is water/oil/Tween 60 at 100/6/1 by volume. Again, the lumped model can be used for predicting the temperature of water mixture and the mass of slurry ice quite well.

08/02725 Thermal and flow behaviors in heat transportation container using phase change material

Kaizawa, A. *et al. Energy Conversion and Management*, 2008, 49, (4), 698–706.

A waste heat transportation system using a phase change material (PCM) – the so-called trans-heat (TH) system that uses a direct heat exchanger with an extremely simple structure to store and release the latent heat of PCMs – is quite attractive. The purpose of this paper is to study the thermal and flow behaviours in a TH container in which the solidification and melting of PCMs are directly observed by using a two-dimensional, roundly sliced model. In the heat storage experiments, it was observed that many HTO channels within the solid PCM in the early stage, which caused a large heat storage rate. In the final stage, the heat storage rate was extremely small; leading to the formation of a dead zone for the solid PCM in the lower part of both ends of the container owing to the non-uniform distribution of the HTO. In the heat release experiments, interestingly, the observed features of the solid PCMs were classified into three types; formation and growth of solidified PCM masses in the inlet pipes, sinking of solidified PCM particles and foaming oil coated by solidified PCM film. In particular, the sinking of the solidified PCM particles was effective for mixing the liquid PCM and cooling the container uniformly. The results revealed that the shape of the inlet pipes should be designed by considering their position, the number of pipes and the nozzle angle using a sophisticated heat and fluid flow model to maximize the heat exchange rate.

08/02726 Thermal comfort assessment and application of radiant cooling: a case study

Memon, R. A. *et al. Building and Environment*, 2008, 43, (7), 1185–1196.

A field assessment of thermal comfort was conducted at Mehran University of Engineering and Technology, situated in the subtropical region of Pakistan. The results show that people of the area were feeling thermally comfortable at effective temperature of 29.85 °C (operative temperature 29.3 °C). A comparison of this neutral effective temperature was made with the neutral effective temperature determined from adaptive models. It is found that the neutral effective temperature determined during this study closely match that of the adaptive model based on either indoor temperature or both indoor and outdoor temperatures. The results of thermal acceptability assessment show that more than 80% of occupants were satisfied at an effective temperature of 32.5 °C, which is 6.5 °C above the upper boundary of ASHRAE thermal comfort zone. Naturally ventilated classrooms and air-conditioned offices of the University were simulated using TRNSYS system simulation program for two cases, once when conventional air-conditioning is used for providing thermal comfort, and when comfort is achieved through radiant cooling. In the simulation, a cooling tower was used to regenerate cooling water for the radiant cooling system. Energy consumption was estimated from simulation of both cases. The results show that it is possible to achieve thermal comfort for most of the time of the year through the use of radiant cooling without a risk of condensation of moisture from air on the radiant cooling surfaces. A comparison of the energy consumption estimates show that savings of 80% is possible in case thermal comfort is achieved through radiant cooling instead of conventional air-conditioning.

08/02727 Thermodynamic modelling of a two-stage absorption chiller driven at two-temperature levels

Figueredo, G. R. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 211–217.

The thermodynamic model developed in this paper considers (i) the external irreversibilities of the endoreversible models; (ii) the irreversibilities due to heat losses; and (iii) the generation of internal entropy due to pressure drops and the temperature and concentration gradients. The authors considered: (i) external heat losses between the generators of high and intermediate pressures and the ambient and between the ambient and the evaporator; and (ii) internal heat losses from the generators towards the condensers and from the absorber towards the evaporator. This simple but precise model faithfully represents the trend towards efficiency variation at partial loads. The model was used to analyse the behaviour of a water–LiBr double-stage absorption chiller with 200 kW of cooling power. This machine can operate in summer as a double-stage chiller driven by heat at 170 °C from natural gas, as a single-stage chiller driven by heat at 90 °C from solar energy, or simultaneously in combined mode at both temperatures. It can also operate in winter in 'double-lift' mode for heating with a driving heat at 170 °C from natural gas.

08/02728 Transient thermal characteristics of airborne electronic equipment with discrete hot bands in square cavities

Baïri, A. *Applied Energy*, 2008, 85, (10), 951–967.

This study is concerned with the thermal regulation of electronic circuits confined in a closed cubical air-filled cavity. The hot active wall, which represents the electronic equipment, is composed of three parallel discrete heat source bands subjected to a constant heat flux, separated by two adiabatic bands. The second active wall is an isothermal cold plate and is facing the hot wall. The cavity channel is considered adiabatic. Transient heat exchanges through two-dimensional natural convection are analysed for several configurations obtained through varying the inclination angle of the active wall with respect to gravity. The numerical approach conducted with the finite volumes method allowed the derivation of the thermal and dynamic characteristics of the cavity. The thermal evolution of the sources does not show any local temperature peaks that could exceed the maximum allowable temperature set by the electronic components manufacturers. This guarantees the normal operation of the equipment. The numerical analysis is complemented by experimental measurements that validate the used model and allow the correct sizing of the airborne electronic circuits.

11 ENGINES

Power generation and propulsion, electrical vehicles

08/02729 Aviation fuel JP-5 and biodiesel on a diesel engine

Korres, D. M. *et al. Fuel*, 2008, 87, (1), 70–78.

Naval aviation turbine fuel, JP-5, has been accepted as alternative to JP-8 in the frame of the single fuel policy. This has resulted in some ongoing research on JP-5 fuel for its application as a naval single fuel. The necessity to cope with the environmental problems identified in the process of implementing the single fuel policy as well as the strict requirements of modern diesel engines has lead to the need of improved single fuel quality. The development of biomass derived substitutes for diesel, such as biodiesel, is a possible attractive solution. The present paper is an effort to evaluate JP-5 along with diesel and biodiesel for use in a diesel engine. These fuels were used alone and in various mixture fractions in a single cylinder stationary diesel engine in order to evaluate their performance under defined operating conditions of the engine. JP-5 reduced both the NO_x and particulate matter emissions as compared to the reference fuel case. Biodiesel significantly lowered particulate emissions, but slightly increased NO_x emissions and fuel consumption. Fuel sulfur content has an undesired effect on smoke opacity. Biodiesel increased the fuel consumption when added to petroleum fuels and the increase was larger at high engine loads. Diesel and JP-5 showed similar fuel consumption, with diesel consumption increasing at high engine loads. Ternary blends showed similar behaviour. The blends with lower biodiesel content showed lower volumetric fuel consumption.

08/02730 Design and performance optimization of GPU-3 Stirling engines

Timoumi, Y. *et al. Energy*, 2008, 33, (7), 1100–1114.

To increase the performance of Stirling engines and analyse their operations, a second-order Stirling model, which includes thermal losses, has been developed and used to optimize the performance and design parameters of the engine. This model has been tested using the experimental data obtained from the General Motor GPU-3 Stirling engine prototype. The model has also been used to investigate the effect of the geometrical and physical parameters on Stirling engine performance and to determine the optimal parameters for acceptable operational gas pressure. When the optimal design parameters are introduced in the model, the engine efficiency increases from 39% to 51%; the engine power is enhanced by approximately 20%, whereas the engine average pressure increases slightly.

08/02731 Digital simulation and hardware implementation of a simple scheme for direct torque control of induction motor

Prasad, D. *et al. Energy Conversion and Management*, 2008, 49, (4), 687–697.

A simple scheme that allows fast control of induction motor torque has been presented. It is different from the conventional direct torque control (DTC) scheme in the sense that it does not use the popular DTC switching table. Also, it does not require use of any online fast computing device like a microprocessor, personal computer or digital signal processor. The proposed scheme uses only commonly used discrete hardware components for its implementation. The experimental results obtained from the hardware realization of the proposed scheme are found to be in close agreement with the simulation results.

08/02732 Effect of unbalanced voltage on windings temperature, operational life and load carrying capacity of induction machine

Gnacinski, P. *Energy Conversion and Management*, 2008, 49, (4), 761–770.

This paper investigates the influence of the CVUF angle on the windings temperature rise and the derating factor of an induction machine supplied with unbalanced voltage. The effect of simultaneous voltage unbalance and harmonics on its operational life is analysed as well. The results of calculations and experimental investigations are presented for two induction cage machines of rated power 3 and 5.5 kW.

08/02733 Emissions from large-scale medium-speed diesel engines: 1. influence of engine operation mode and turbocharger

Sarvi, A. *et al. Fuel Processing Technology*, 2008, 89, (5), 510–519.

The operation of four-stroke diesel engines in either propulsion or generator mode application has a strong influence on gaseous, smoke (soot) and particulates emissions. Tests were made with a supercharged after-cooled large-scale diesel engine (mean speed ~500 rpm, power per cylinder ~1 MW) burning mainly heavy fuel oil. Gaseous emissions (NO_x, CO, HC) were measured according to the IMO technical code, smoke (soot) emissions were determined optically and particulate matter (PM) was measured using a gravimetric impactor for five size fractions. Impact on gaseous emissions, smoke (soot) and PM was found when analysing the effects of the engine operating mode, fuel nozzle, start of injection, and load (speed). Results show that the exhaust emission was also highly dependent on the engine turbocharger system, especially the by-pass control, but was not affected by waste gate control. The gaseous and soot emissions were less for the generator mode in the total load region, decreasing with the load. PM emissions were found to decrease with the load for the propulsion mode, while showing an increase with the load for the generator mode.

08/02734 Emissions from large-scale medium-speed diesel engines: 2. influence of fuel type and operating mode

Sarvi, A. *et al. Fuel Processing Technology*, 2008, 89, (5), 520–527.

This paper addresses gaseous emissions smoke (soot) and particulate matter in large-scale diesel engine exhaust. The test engine was a large-scale turbocharged, after-cooled mean speed (~500 rpm) direct-injection diesel engine and the power per cylinder was about 1 MW. Emission measurements were carried out on burning heavy fuel (HFO) and light fuel (LFO) oils. The test modes for the investigation were a propulsion mode (marine application) and a generator mode (power plant application). Gaseous emissions were measured according to the IMO technical code, smoke (soot) emissions were determined optically and particulate matter (PM) was measured by gravimetric impactor designed for five size fractions. In comparison the emissions from HFO and LFO utilizations indicate slightly higher NO and CO emissions for HFO, while LFO gives clearly higher emissions of hydrocarbons. Emissions of soot and CO appeared to correlate very well, being very high for both fuels throughout the propulsion mode and low load, otherwise being similar for both modes. PM emissions are more than three times higher with HFO than with LFO and appear to decrease with the load except for HFO during the generator mode where an increase of PM emissions with the load is seen. Some data on sampled particles is given.

08/02735 Experimental evaluation of local instantaneous heat transfer characteristics in the combustion chamber of air-cooled direct injection diesel engine

Rakopoulos, C. D. and Mavropoulos, G. C. *Energy*, 2008, 33, (7), 1084–1099.

An experimental analysis is conducted investigating the differences between the variations of overall and local instantaneous heat transfer coefficients, during the engine cycle, in the combustion chamber walls of a direct injection, air-cooled diesel engine located at the authors' laboratory. For this purpose, a novel experimental installation is developed, which separates the engine transient temperature signals into two parts, namely the long- and the short-term response ones, processed in two independent data acquisition systems. Moreover, a new pre-amplification unit for fast response thermocouples, appropriate heat flux sensors and an object-oriented control code for fast data acquisition have been designed and applied. Experimentally obtained cylinder pressure diagrams are used as a basis for the calculation of the overall heat transfer coefficients, whereas one-dimensional heat conduction theory with Fourier analysis techniques, combined with an iterative procedure between calculated and measured temperature data, are implemented in order to calculate the instantaneous local heat transfer coefficients in the engine cylinder. Analysis of the experimental results reveals interesting aspects of transient engine heat transfer. Significant differences are disclosed between the overall and local heat transfer coefficient variations, with the importance of the latter one on engine design being emphasized. The local heat transfer coefficient on the cylinder head is quantified based on the experimental data. The effect of engine speed and load as well as of the air swirling motion on the heat transfer variations are presented. From the analysis results it is concluded that the instantaneous heat transfer variation is non-uniform, unlike its values calculated from standard correlations that assume spatial uniformity, noting that such information, especially for air-cooled diesel engines, seems to be very scarce in the open literature.

08/02736 Experimental investigation of gasoline fumigation in a single cylinder direct injection (DI) diesel engine

Şahin, Z. *et al. Energy*, 2008, 33, (8), 1298–1310.

In the presented study, the effects of gasoline fumigation have been investigated experimentally in a single cylinder direct injection diesel engine. Gasoline has been introduced into the inlet air flow using an elementary carburetor and no other modification on the engine has been done. The effects of 2%, 4%, 6%, 8% and 10% (by vol.) gasoline fumigation have been investigated experimentally at the speeds of (900–1600) (rpm) and at the selected compression ratios of (18–23). From the experimental results it is determined that by application of gasoline fumigation effective power output increases at the levels of 4–9%, effective efficiency increases by approximately 1.5–4% and specific fuel consumption decreases by approximately 1.5–4%. It is also determined that 4–6% fumigation ratio range is the most favourable percentage interval of gasoline at the selected compression ratios for this engine. Because cost of gasoline is higher than diesel fuel in Turkey as well as in many of the other countries and the decrease ratio of specific fuel consumption is low, gasoline fumigation is not economic for this engine. In the presented study, heat balance tests have also been performed for 18 and 21 compression ratios. The heat balance has been investigated experimentally in respect of effective power, heat rejected to the cooling water, heat lost through exhaust, and other losses (unaccounted-for losses). Heat lost through exhaust decreases until 4–6% gasoline fumigation ratios and after these fumigation ratios it starts to increase because of increasing exhaust gas temperature. Heat rejected to the cooling water decreases at low fumigation ratios, but at high fumigation ratios it increases. Other losses generally exhibit an increasing tendency at low fumigation ratios.

08/02737 Experimental study for sensorless broken bar detection in induction motors

Çaliş, H. and Çakir, A. *Energy Conversion and Management*, 2008, 49, (4), 854–862.

This study presents experimental results of sensorless broken bar detection in induction motors based on fluctuations of the stator current zero crossing instants before actual breakdown occurs. These fluctuations are sensed by a microcontroller, and transferred to a computer for monitoring the amplitude changes on specific frequency components using fast Fourier transformation algorithms. The motor current signal is also monitored for verification purposes. The main reasons of rotor faults are broken bars, end ring faults and bearing faults. Most recent efforts are focusing on current spectrum analysis, as the current signal is easily accessible for all induction motors. Instead of sampling motor current with a high resolution analog to digital converter, zero crossing instants are recorded as the waveforms cross zero. Fluctuations in the intervals between successive zero crossings of the three phase current waveforms are analysed in the frequency domain. Broken bars and end ring breakages, supply unbalances, rotor eccentricities and shaft misalignment faults are distinguished by monitoring amplitude changes of the $2sf$, f_r, and $2f$ spectral components, where s is the motor slip, f is supply frequency and f_r is rotor speed. Appearance of only the $2sf$ component in zero crossing times (ZCT) of the signal spectrum implies rotor faults. The $2f$ component occurs only when supply is unbalanced or in the case of stator winding faults. Separation of these two faults is implemented by monitoring both components. In addition, when there is additional rotor eccentricity due to bearing deterioration or shaft misalignment, it is also necessary to monitor the f_r fault signature component to distinguish mixed faults. It may be necessary to include additional signals such as motor vibration or temperature to extend the reliability of the fault detection system for critical machines.

08/02738 Gradient effects on two-color soot optical pyrometry in a heavy-duty DI diesel engine

Musculus, M. P. B. *et al. Combustion and Flame*, 2008, 153, (1–2), 216–227.

Two-colour soot optical pyrometry is a widely used technique for measuring soot temperature and volume fraction in many practical combustion devices, but line-of-sight soot temperature and volume fraction gradients can introduce significant uncertainties in the measurements. For diesel engines, these uncertainties usually can only be estimated based on assumptions about the soot property gradients along the line of sight, because full three-dimensional transient diesel soot distribution data are not available. Such information is available, however, from multidimensional computer model simulations, which are phenomenologically based, and have been validated against available in-cylinder soot measurements and diesel engine exhaust soot emissions. Using the model-predicted in-cylinder soot distributions, uncertainties in diesel two-colour pyrometry data are assessed, both for a conventional high-sooting, high-temperature combustion (HTC) operating condition, and for a low-sooting, low-temperature combustion (LTC) condition. The simulation results confirm that the two-colour soot measurements are strongly biased toward the properties of the hot soot. For the HTC condition, line-of-sight gradients in soot temperature span 600 K, causing relatively large errors. The two-colour temperature is 200 K higher than the soot-mass-averaged value, while the two-colour volume fraction is 50% lower. For the LTC condition, the two-colour measurement errors are half as large as for the HTC condition, because the model-predicted soot temperature gradients along the line of sight are half as large. By contrast, soot temperature and volume fraction gradients across the field of view introduce much smaller errors of less than 50 K in temperature and 20% in volume fraction.

08/02739 In-cylinder flows of a motored four-stroke engine with flat-crown and slightly concave-crown pistons

Huang, R. F. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (5), 1156–1167.

The temporal and spatial evolution processes of the in-cylinder flow structures and turbulence intensities in the symmetry and offset planes of a motored four-valve, four-stroke engine during the intake and compression strokes are diagnosed by using a particle image velocimeter. Two pistons of different crown shapes (flat-crown and slightly concave-crown pistons) are studied. The inception, establishment, and evolution of the tumbling vortical flow structures during the intake and compression strokes are clearly depicted. Quantitative strengths of the rotating vortical flow motions are presented by a dimensionless parameter, the tumble ratio, which can represent the mean angular velocity of the vortices in the target plane. The turbulence intensity of the in-cylinder flow is also calculated by using the measured time-varying velocity data. The results show that the flat-crown piston induces higher bulk-averaged tumble ratio and turbulence intensity than the slightly concave-crown piston does because the tumble ratio and turbulence generated by the flat-crown piston in the offset planes during the compression stroke are particularly large. The engine with the flat-crown piston also presents larger torque and power outputs and lower hydrocarbon emission than that with the slightly concave-crown piston. This might be caused by the enhanced combustion in the engine cylinder due to the stronger tumble ratio and turbulence intensity.

08/02740 Oscillatory flow in microporous media applied in pulse – tube and Stirling – cycle cryocooler regenerators

Cha, J. S. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (6), 1264–1278.

Pulse tube and Stirling cryocoolers are widely used in aerospace and other high-demand application. A key component in these systems is the regenerator, which is typically a microporous metallic structure that is subject to periodic flow of a cryogenic fluid. The thermal and hydrodynamic irreversibilities in the regenerator, which play crucial roles with respect to the efficiency of the aforementioned cycles, are poorly understood, however. In this investigation experiments were performed where pressure drop associated with steady-periodic (axial and lateral (radial)) flows of helium in test sections packed with several widely used pulse tube and Stirling cryocooler regenerator fillers were measured under ambient temperature conditions. A computational fluid dynamic (CFD) – assisted method was developed for the analysis and interpretation of the experimental data, whereby the permeability and inertial coefficients that lead to agreement between the data and the predictions of CFD simulations were iteratively obtained. The directional permeability and Forchheimer inertial coefficients were thus obtained for the tested regenerator fillers, and were found to be independent of the frequency of flow oscillations for the frequency range 5–60 Hz. The results also show that the oscillatory flow hydrodynamic parameters are different than steady-flow parameters representing similar flow conditions.

08/02741 Prediction of windings temperature rise in induction motors supplied with distorted voltage

Gnacinski, P. *Energy Conversion and Management*, 2008, 49, (4), 707–717.

One of the features of ship power systems is a different level and intensity of disturbances appearing during routine operation – the rms voltage value and frequency deviation, voltage unbalance and waveform voltage distortion. As a result, marine induction machines are exposed to overheating due to the lowered voltage quality. This paper is devoted to windings temperature rise prediction in marine induction cage machines supplied with distorted voltage, which means real voltage conditions. The proposed method of prediction does not require detailed knowledge of the thermal properties of a machine. Although the method was developed for marine induction motors, it is applicable for industry machines supplied with distorted voltage. It can also be generalized and used for estimation of the steady state windings temperature rise of any electrical machinery in various work conditions.

Hybrid engine systems

08/02742 A simplistic model to study the influence of film cooling on low temperature hot corrosion rate in coal gas/syngas fired gas turbines

Krishnan, V. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (5–6), 1049–1060.

The present paper is an attempt to establish an analytical study of low temperature hot corrosion (LTHC) in the context of high temperature turbines using coal gas or syngas with trace amount of sulfur in the fuel. LTHC in the presence of film cooling is explored using a simple analytical approach and heat and mass transfer analogy with film cooling air temperatures from 450 °C to 550 °C, hot gas stream temperature of 1425 °C and 0.5% of sulfur concentration in the fuel. For all the cooling air temperatures studied here, film cooling augments corrosion when the mainstream velocity is high. However, reduction in the mainstream velocity results in the suppression of corrosion after employing film cooling. A sharp peak in corrosion rate close to the cooling hole ($<10s$) is also seen. As the base super alloy is vulnerable to hot corrosion in this region, designers should consider the high corrosion rate seriously. The present model provides a simple baseline prediction methodology and sets direction for optimization needs.

08/02743 Agent-based power sharing scheme for active hybrid power sources

Jiang, Z. *et al. Journal of Power Sources*, 2008, 177, (1), 231–238.

The active hybridization technique provides an effective approach to combining the best properties of a heterogeneous set of power sources to achieve higher energy density, power density and fuel efficiency. Active hybrid power sources can be used to power hybrid electric vehicles with selected combinations of internal combustion engines, fuel cells, batteries, and/or supercapacitors. They can be deployed in all-electric ships to build a distributed electric power system. They can also be used in a bulk power system to construct an autonomous distributed energy system. An important aspect in designing an active hybrid power source is to find a suitable control strategy that can manage the active power sharing and take advantage of the inherent scalability and robustness benefits of the hybrid system. This paper presents an agent-based power sharing scheme for active hybrid power sources. To demonstrate the effectiveness of the proposed agent-based power sharing scheme, simulation studies are performed for a hybrid power source that can be used in a solar car as the main propulsion power module. Simulation results clearly indicate that the agent-based control framework is effective to coordinate the various energy sources and manage the power/voltage profiles.

08/02744 Amorphous cobalt–boron/nickel foam as an effective catalyst for hydrogen generation from alkaline sodium borohydride solution

Dai, H.-B. *et al. Journal of Power Sources*, 2008, 177, (1), 17–23.

Low cost and catalytically effective transition metal catalysts are of interest for the development of on-board hydrogen generation systems for fuel-cell vehicles. In the present study a modified electroless plating method was developed for the preparation of amorphous Co–B catalyst supported on Ni foam. Compared to the conventional electroless plating method, the newly developed method is more effective and produces Co–B catalyst with much higher catalytic activity. The catalytic activity of the supported Co–B catalyst was found to be highly dependent on the plating times and calcination conditions. Through optimization of these preparation conditions, the authors were able to prepare a catalyst capable of a hydrogen generation rate of $11\,l\,(\text{min g})^{-1}$ (catalyst) in a 20 wt.% $NaBH_4$ + 10 wt.% NaOH solution. Preliminary phase analyses and microstructure characterization were performed to understand the effects of preparation conditions on the catalytic activity of the Co–B catalyst.

08/02745 An experimental study on the performance parameters of an experimental CI engine fueled with diesel–methanol–dodecanol blends

Bayraktar, H. *Fuel*, 2008, 87, (2), 158–164.

The effects of using diesel–methanol–dodecanol blends including methanol of various proportions on a CI engine performance are experimentally investigated. The methanol concentration in the blend has been changed from 2.5% to 15% with the increments of 2.5%, and 1% dodecanol was added into each blend to solve the phase separation problem. Experimental study has been conducted on a single-cylinder, water-cooled CI engine. The engine has been operated at different compression ratios (19, 21, 23 and 25) and the engine speed was varied from 1000 to 1600 rpm at each compression ratio. The performance parameters such as torque, effective power, specific fuel consumption and effective efficiency for each blend at various conditions are calculated depending on the experimental data. It was concluded that among the different blends, the blend including 10% methanol (DM10) is the most suited one for CI engines from the engine performance point of view. Improvements obtained up to 7% in performance parameters with this blend without any modification to engine design and fuel system are very promising.

08/02746 Design and manufacturing of a V-type Stirling engine with double heaters

Batmaz, I. and Üstün, S. *Applied Energy*, 2008, 85, (11), 1041–1049.

Under the consideration of the solar energy potential of Turkey, a V-type Stirling engine having two heaters was designed, optimized and then manufactured. The prototype engine was tested in laboratory condition using an electrical heating system. Tests were conducted within the temperature range of 650–1000 °C with 50 °C increments. The pressure ranged from the ambient value to 2 bar with 0.5 bar increments at each stage of temperature. The maximum power was obtained at 950 °C and 1.0 bar charge pressure as 118 W.

08/02747 Investigation of purified sulfate turpentine on engine performance and exhaust emission

Yumrutaş, R. *et al. Fuel*, 2008, 87, (2), 252–259.

This study deals with an experimental work that aims to examine effects of purified sulfate turpentine obtained from a kraft pulp mill in Turkey on an engine performance and exhaust emissions of a spark ignition engine. Three fuel samples are used to test the performance and emission of a 1300 cc engine manufactured by TOFAŞ. They are pure gasoline with 98-octane number and two other gasoline–turpentine fuel samples obtained by blending gasoline with turpentine in ratios of 5% and 10% on basis of total mass of the fuel. The thermophysical properties of the fuels are acquired by density, viscosity, flash and fire points, sulfur content, heating value and distillation tests. The experimental results showed that the turpentine has a positive effect on the engine performance parameters, such as brake power, thermal efficiency, mean effective pressure and specific fuel consumption. However, the turpentine also increases pollutant NO_x, unburned hydrocarbon contents and exhaust temperature, but it decreases CO concentration in the exhaust. It is observed that utilization of the sulfate turpentine alone is not viable and it needs to be used as an additive into gasoline to some extent, thereby providing a viable alternative to pure gasoline.

08/02748 Multi-zone modeling of combustion and emissions formation in DI diesel engine operating on ethanol–diesel fuel blends

Rakopoulos, C. D. *et al. Energy Conversion and Management*, 2008, 49, (4), 625–643.

A multi-zone model for calculation of the closed cycle of a direct injection (DI) diesel engine is applied for the interesting case of its operation with ethanol–diesel fuel blends, the ethanol (bio-fuel) being considered recently as a promising extender to petroleum distillates. This is a two dimensional, multi-zone model with the issuing fuel jets divided into several discrete volumes, called ‘zones’, formed along and across the direction of the fuel injection. The model follows each zone, with its own time history, as the spray penetrates into the swirling air environment of the combustion chamber. Droplet evaporation and jet mixing models are used to determine the amount of fuel and entrained air in each zone available for combustion. The mass, energy and state equations are applied in each zone to provide local temperatures and cylinder pressure histories. The concentrations of the various constituents are calculated by adopting a chemical equilibrium scheme for the C–H–O–N system of eleven species considered, together with chemical rate equations for calculation of nitric oxide (NO) and a model for net soot formation. The results compare well with the corresponding measurements from an experimental investigation conducted on a fully automated test bed, standard ‘Hydra’, DI diesel engine operated with ethanol–diesel fuel blends containing 5%, 10% and 15% (by vol.) ethanol. Iso-contour plots of equivalence ratio, temperature, NO and soot inside the cylinder at various instants of time, when using these ethanol–diesel fuel blends against the diesel fuel (baseline fuel), reveal how the widely differing properties of ethanol in these blends, against the normal diesel fuel, affect greatly the combustion mechanism and the related emitted pollutants.

08/02749 Performance and emissions of bus engine using blends of diesel fuel with bio-diesel of sunflower or cottonseed oils derived from Greek feedstock

Rakopoulos, C. D. *et al. Fuel*, 2008, 87, (2), 147–157.

An experimental investigation is conducted to evaluate the use of sunflower and cottonseed oil methyl esters (bio-diesels) of Greek origin as supplements in the diesel fuel at blend ratios of 10/90 and 20/80, in a fully instrumented, six-cylinder, turbocharged and after-cooled, direct injection (DI), Mercedes-Benz, mini-bus diesel engine installed at the authors’ laboratory. The tests are conducted using each of the above fuel blends, with the engine working at two speeds and three loads. Fuel consumption, exhaust smokiness and exhaust regulated gas emissions such as nitrogen oxides, carbon monoxide and total unburned hydrocarbons are measured. The differences in the measured performance and exhaust emissions from the baseline operation of the engine, i.e. when working with neat diesel fuel, and the two bio-diesels are determined and compared. Theoretical aspects of diesel engine combustion with the differing physical and chemical properties of these blends, aid the correct interpretation of the observed engine behaviour.

08/02750 Use of a catalyst layer for anode-supported SOFCs running on ethanol fuel

Ye, X.-F. *et al. Journal of Power Sources*, 2008, 177, (2), 419–425.

Solid oxide fuel cells (SOFCs) operating directly on hydrocarbon fuels have attracted much attention in recent years. A two-layer structure anode running on ethanol was fabricated by tape casting and screen printing technology in this paper, the addition of a $Cu–CeO_2$ catalyst layer to the supported anode surface yielded much better performance in ethanol fuel. The effect that the synthesis conditions of the catalyst layer have on the performances of the composite anodes was investigated. Single cells with this anode were also fabricated, of which the maximum power density reached $566\,mW\,cm^{-2}$ at 800 °C operating on ethanol steam. Long-term performance of the anodes was presented by discharging for a period as long as 80 h without carbon deposition.

Transport battery development

08/02751 A new phase in Ni–Sn–P system and its property as an anode material for lithium-ion batteries

Xia, Z. P. *et al. Materials Characterization*, 2008, 59, (9), 1324–1328.

A new metastable phase was synthesized by ball milling. The new phase is tetragonal with lattice parameters $a = 3.671\,Å$ and $c = 4.033\,Å$. It was found that the new phase transformed into equilibrium orthorhombic Ni_2SnP phase at 973 K. The initial capacity of the lithium battery with the tetragonal Ni_2SnP phase as anode material reaches 500.4 mAh/g, but decreases to 181.8 mAh/g after 25 cycles. However, its initial irreversible capacity is 102 mAh/g, which makes it a promising anode material.

08/02752 Al-substituted α-cobalt hydroxide synthesized by potentiostatic deposition method as an electrode material for redox-supercapacitors

Gupta, V. *et al. Journal of Power Sources*, 2008, 177, (2), 685–689.

Al-substituted α-cobalt hydroxide was prepared by a potentiostatic deposition process at $-1.0\,V$ (vs Ag/AgCl) onto stainless steel electrodes by using a mixed aqueous solution of cobalt nitrate and aluminum nitrate. Their structure and surface morphology were studied by using X-ray diffraction analysis, energy dispersive X-ray spectroscopy and scanning electron microscopy. The SEM images showed changes in the nanostructure of α-cobalt hydroxide by the addition of Al. Galvanostatic charge–discharge curves showed a drastic improvement in the capacitive characteristics of α-cobalt hydroxide, with a specific energy increase from 11.3 to $18.7\,Wh\,kg^{-1}$ by the substitution of just 8 at.% Al, and a specific capacitance of $843\,F\,g^{-1}$ between 0 and 0.4 V. The cycle stability data suggest no significant changes in the discharge characteristics of α-cobalt hydroxide by the addition of Al.

08/02753 Battery switch array system with application for JPL’s rechargeable micro-scale batteries

Alahmad, M. *et al. Journal of Power Sources*, 2008, 177, (2), 566–578.

A battery switch array system is developed for solid-state rechargeable micro-scale lithium batteries, designed and developed by Jet Propulsion Laboratory (JPL), California Institute of Technology, for aerospace applications. The heart of the system is a topology unique in its dynamic reconfiguration ability by providing selective connection and isolation and versatile in its core design by incorporating passive, active or energy storage elements. It allows up to N-batteries to be connected in any desired configuration; providing maximum voltage, maximum capacity and a voltage/capacity ratio. This battery switch array system is part of a power management system that is developed to utilize these features and provide for multiple charging algorithms, real time status information and fault tolerant capabilities. A two microbattery prototype circuit is built using a microprocessor-based controller for verification of the system design and its features. The topology and its features will be explored in this paper to provide methods for modular and scalable energy storage system design.

08/02754 Delphi, Peterbilt power truck cab with SOFC APU

Shaffer, S. R. *Fuel Cells Bulletin*, 2008, 2008, (9), 3.

In the USA, Delphi Corporation and Peterbilt Motors have successfully demonstrated a Delphi solid oxide fuel cell (SOFC) auxiliary power unit (APU) powering a Peterbilt model 386 truck’s ‘hotel’ loads. During recent testing at Peterbilt’s Texas headquarters, the Delphi SOFC provided power for the model 386’s electrical system and air-conditioning and maintained the truck’s batteries – with its standard diesel engine turned off. Delphi’s SOFC technology directly addresses increasingly stringent anti-idling legislation and other proposals that deal with commercial truck emissions, noise and fuel consumption. By limiting truck idling time and running an SOFC instead of the main engine, emissions are reduced, noise is nearly eliminated, and operators realize significant fuel savings. The new Delphi technology will be able to use a variety of fuels, including natural gas, diesel, biodiesel, propane, gasoline, coal-derived fuel and military logistics fuel. In addition to its fuel flexibility, the SOFC will be compact in size. The demonstration took place in June, and built on development work that has been supported by the Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE) and the Solid State Energy Conversion Alliance (SECA) program. The Peterbilt/Delphi test replicated a typical trucker’s day to evaluate the real-world usefulness and capacity of the SOFC. First, the SOFC APU was brought to operating temperature with the truck’s main engine running. This simulated starting the SOFC APU during normal, on-road driving conditions. Once the SOFC APU was at temperature and available to provide power, the truck’s main engine was turned off, simulating the beginning of a rest period. During the rest period, the SOFC APU powered the truck’s electrical loads, including the electric air-conditioner, radio, citizens band radio, and lights. It also charged the truck's battery. After 10 h, representing running overnight, the truck's main engine was restarted to simulate the driver beginning to drive for the next day. Throughout the test, the SOFC APU provided an average of 800 W of electric power to the truck.

08/02755 Dual active material composite cathode structures for Li-ion batteries

Whitacre, J. F. *et al. Journal of Power Sources*, 2008, 177, (2), 528–536.
The efficacy of composite Li-ion battery cathodes made by mixing active materials that possessed either high-rate capability or high specific energy was examined. The cathode structures studied contained carbon-coated $LiFePO_4$ and either $Li[Li_{0.17}Mn_{0.58}Ni_{0.25}]O_2$ or $LiCoO_2$. These active materials were arranged using three different electrode geometries: fully intermixed, fully separated, or layered. Discharge rate studies, cycle-life evaluation, and electrochemical impedance spectroscopy studies were conducted using coin cell test structures containing Li-metal anodes. Results indicated that electrode configuration was correlated to rate capability and degree of polarization if there was a large differential between the rate capabilities of the two active material species.

08/02756 Polytriphenylamine: a high power and high capacity cathode material for rechargeable lithium batteries

Feng, J. K. *et al. Journal of Power Sources*, 2008, 177, (1), 199–204.
Polytriphenylamine (PTPAn) was chemically synthesized and tested as a cathode material for high-rate storage and delivery of electrochemical energy. It is found that the polymer has not only superior high power capability but also high energy density at prolonged cycling. At a moderate rate of 0.5*C*, PTPAn gives a high average discharge voltage of 3.8 V and quite a high capacity of 103 $mAh\,g^{-1}$, which is very close to the theoretical capacity (109 $mAh\,g^{-1}$) as expected from one electron transfer per triphenylamine monomer. Even cycled at a very high rate of 20*C*, the polymer can still deliver a capacity of 90 $mAh\,g^{-1}$ at 1000th cycle with a nearly 100% coulombic efficiency. The excellent electrochemical performances of PTPAn are explained from the structural specificity of the polymer where the radical redox centres are stabilized and protected by conductive polymeric backbone, making the radical redox and charge-transporting processes kinetically facile for high-rate charge and discharge.

08/02757 Reliability and availability analysis of low power portable direct methanol fuel cells

Sisworahardjo, N. S. *et al. Journal of Power Sources*, 2008, 177, (2), 412–418.
This paper presents a methodology for modelling and calculating the reliability and availability of low power portable direct methanol fuel cells (DMFCs). System reliability and availability are critical factors for improving market acceptance and for determining the competitiveness of the low power DMFC. Two techniques have been used for analysing the system reliability and availability requirements for various system components. Reliability block diagram (RBD) is formed based on the failure rates of irreparable system components. A state-space method is developed to calculate system availability using the Markov model (MM). The state-space method incorporates three different states – operational, derated, and fully faulted states. Since most system components spend their lifetime in performing normal functional task, this research is focused mainly on this operational period. The failure and repair rates for repairable DMFC systems are estimated on the basis of a homogeneous Poisson process (HPP) and exponential distribution. Extensive analytical modelling and simulation study has been performed to verify the effectiveness of the proposed technique.

08/02758 Separator profile selection for optimal battery performance

Whear, J. K. *Journal of Power Sources*, 2008, 177, (1), 226–230.
Battery performance, depending on the application, is normally defined by power delivery, electrical capacity, cycling regime and life in service. In order to meet the various performance goals, the Battery Design Engineer can vary things such as grid alloys, paste formulations, number of plates and methods of construction. Another design option available to optimize the battery performance is the separator profile. The goal of this paper is to demonstrate how separator profile selection can be utilized to optimize battery performance and manufacturing efficiencies. Also time will be given to explore novel separator profiles which may bring even greater benefits in the future. All major lead-acid application will be considered including automotive, motive power and stationary.

08/02759 Single-ion conductors for lithium batteries via silica surface modification

Zhang, H. *et al. Journal of Power Sources*, 2008, 177, (2), 561–565.
Single-ion conductors (SICs) have been prepared by free-radical polymerization of sulfonic acid-containing monomer on high-purity silica surface that was first tailored with unsaturated functionality using a silanation reaction. It was found that steric effects limited polyelectrolyte surface loading even when large amount of silane molecules were grafted by forming a cross-linked structure. The results indicate that large surface area is an important factor to achieve high-surface loading of ionic moieties. Composite electrolytes were prepared by dispersing these SICs in aprotic solvents. The effects of filler content and solvent on ionic conductivity were investigated.

08/02760 Studies on the degradation of Li-ion batteries by the use of microreference electrodes

Zhou, Z. and Notten, P. H. L. *Journal of Power Sources*, 2008, 177, (2), 553–560.
Li-ion batteries made by Lithylene technology were investigated after extensive cycling for a mechanistic understanding of the capacity fade phenomena. The batteries cycled 500 times at 0.5 C were found to lose 13% of their original capacity, which was solely due to the loss of active materials. The negative electrode maintained its capacity to contain Li^+ ions from the positive electrode. The loss of positive electrode materials was attributed to formation and thickening of the surface layer and structure disorder evidenced by XRD measurements. *In situ* impedance measurements revealed that the positive electrode was also responsible for the impedance rise upon cycling. The charge transfer resistance was found to be the most influential factor in the battery impedance, which increased exponentially during cycling. This increase was proved not due to the decrease of positive electrode surface area but resulted from growth of the surface layer.

08/02761 Sulfur–mesoporous carbon composites in conjunction with a novel ionic liquid electrolyte for lithium rechargeable batteries

Wang, J. *Carbon*, 2008, 46, (2), 229–235.
Sulfur coated mesoporous carbon (S–C) composites have been synthesized and physically characterized by scanning electron microscopy, transmission electron microscopy, Raman spectroscopy, and thermogravimetric analysis. Firstly, the electrochemical properties of the S–C composite cathode materials were tested in a conventional electrolyte consisting of 1 mol/L lithium bistrifluoromethanesulfonimidate in poly(ethylene glycol) dimethyl ether to compare them with pure sulfur electrode. The capacity and cyclic stability of the S–C composite were improved. Then the S–C composites were tested in a novel ionic liquid electrolyte consisting of 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide and lithium bistrifluoromethanesulfonimidate. The capacity and cyclic stability of the S–C composite using the ionic liquid electrolyte were much better than for the sample tested in a conventional organic solvent electrolyte.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

08/02762 A computational method for calculating heat transfer and airflow through a dual-airflow window

Gosselin, J. R. and Chen, Q. *Energy and Buildings*, 2008, 40, (4), 452–458.
An airflow window has great potential for conserving energy and improving indoor air quality in residential buildings. Existing airflow windows use a single airflow path, and their energy performance can be studied using several computational models. A dual-airflow window with triple glazing can conserve more energy than a single-airflow window, because the former works like a cross-counterflow heat exchanger. However, no suitable computer programs can be used to evaluate the energy performance of the dual-airflow window. This paper proposes a four-step computational method that uses both computational fluid dynamics and coded radiation calculations to determine airflow and heat transfer through the window. Experimental tests on a full-scale dual-airflow window system were used to obtain various indoor and outdoor air and window surface temperatures for validating the computer method. The agreement between the computed and measured temperatures is very good.

08/02763 A three-dimensional performance analysis of all-glass vacuum tubes with coaxial fluid conduit

Han, H. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 589–596.

The thermal performance of a solar system composed of parallel, all-glass (double skin) vacuum tubes has been investigated by using a three-dimensional analytical model. Each vacuum tube is equipped with a coaxial fluid conduit for water to flow through and collect the sun's thermal energy. The space between the exterior of the fluid conduit and the glass tube is filled with antifreeze solution to facilitate heat transfer from the solar heated absorber surface to water and to prevent the functional problems due to freezing in frigid weather conditions. Different from one-dimensional analytical models, the three-dimensional model considered in the present analysis enables the prediction of spatial variation of water temperatures as it flows through the coaxial conduit. This is quite useful in extracting major variables for the operation of the solar system using all-glass vacuum tubes as considered in the present investigation.

08/02764 Clay as a dispersant in the catalyst layer for zinc–air fuel cells

Chao, W.-K. *et al. Journal of Power Sources*, 2008, 177, (2), 637–642.
This study proposes a four-layer membrane electrode assembly (MEA) consisting of air-electrode, proton exchange membrane, Zn-electrode with KOH or NaCl aqueous electrolyte and a steel supporter, for use in Zn–air fuel cells. Montmorillonite clay was used to disperse carbon black (CB) and MnO_2 catalyst to improve the performance of the air-electrode. The microstructures of the air-electrode and cell characteristics were investigated by field emission scanning electron microscopy (FE-SEM), optical microscopy (OM) and an electrochemical analyser. The experimental results indicate that the four-layer MEA for Zn–air fuel cells reached a power density of $6\,mW\,cm^{-2}$ (at $10\,mA\,cm^{-2}$) without electrolyte leakage from the cells. The open circuit voltage (OCV) and current density were improved by adding clay to the air-electrode as clay can minimize CB aggregation. In the polarization test, the OCV value (1.40 V) reached approximately 90% of the standard potential (1.65 V) and remained steadily over 48 h. These experimental results demonstrate the four-layer MEA can replace conventional Zn–air fuel cells that utilize aqueous electrolyte.

08/02765 CoO-loaded graphitable carbon hollow spheres as anode materials for lithium-ion battery

Li, F. *et al. Journal of Power Sources*, 2008, 177, (2), 546–552.
A new type of CoO nanoparticles encapsulated by graphitable hollow carbon sphere (GHCS) composite material was synthesized. The core–shell structure CoO/GHCS composite shows the improved cyclability as an anodic material in Li-ion battery. The core–shell composite containing 50 wt% CoO exhibits a reversible capacity of $584\,mAh\,g^{-1}$ at a constant current density of $100\,mA\,g^{-1}$ between 0 and 3.0 V (vs. Li^+/Li), and remains a capacity retention of 95% after 50th cycle. The improvement could be attributed to that the GHCS with a good electronic conductivity and high surface severs as dispersing medium to prevent CoO nanoparticles from aggregating, and provide the enough space to buffer the volume change during the Li-ion insertion and extraction reactions in CoO nanoparticles.

08/02766 Empirical validations of solar gain models for a glazing unit with exterior and interior blind assemblies

Loutzenhiser, P. G. *et al. Energy and Buildings*, 2008, 40, (3), 330–340.
Experiments performed at the Swiss Federal Laboratories for Materials Testing and Research test cell located in Duebendorf, Switzerland were used for empirical validations of building energy simulation programs. Four solar gain experiments were run with either an exterior Venetian blind or an interior mini-blind mounted over a glazing unit with the blind slats in the horizontal position and with the outer slat edge toward the ground tilted downward 45°. Models of the test cell setup were constructed in two distinctive building energy simulation programs, EnergyPlus and HELIOS, and the measured cooling power in the test cell was compared with the simulated cooling powers. For these experiments, the mean percentage of the absolute mean differences for EnergyPlus and HELIOS were all within 6.1 and 7.1%, respectively.

08/02767 Enhancement of pumping performance of electrochemical hydrogen pump by modified electrode

Kawamura, Y. *et al. Fusion Engineering and Design*, 2008, 83, (4), 625–633.
Electrochemical hydrogen pump with ceramic proton conductor membrane has been proposed to apply for a blanket tritium recovery system (BTR) of a fusion reactor. The advantage of this system is that it can apply to the system of low hydrogen pressure, because the driving force of hydrogen permeation is the electric potential difference. Perovskite-type ceramic such as $SrCe_{0.95}Yb_{0.05}O_{3-\alpha}$ (SCO) is one of the candidates of membrane. To apply hydrogen pump to BTR, the enhancement of the hydrogen transportation capability is necessary. Modification of electrode is one of the methods to enhance the hydrogen transportation capability. In this work, the electrodes of platinum (Pt) and palladium (Pd) were attached to the SCO sample by the sputtering method (sputtering electrode), and its electric conductivity and proton conductivity were measured. Then, they were compared with that of the usual Pt paste electrode. Hydrogen transportation capability was enhanced when the sputtering electrode was applied. Especially, in case of the Pd sputtering electrode, the current density which was about 4 or 5 times larger than the usual Pt paste electrode was observed at 0.1% of H_2 concentration.

08/02768 Evaluation of heat flux reduction provided by the use of radiant barriers in clay tile roofs

Michels, C. *et al. Energy and Buildings*, 2008, 40, (4), 445–451.
In Brazilian towns and cities the greatest thermal gain occurs through the roof of single-storey buildings. In this regard, the use of thermal radiation barriers has the function of minimizing the heat flux through the roof. Even though the use of this type of thermal insulation has increased in recent years; there are still no technical standards which address the subject. Thus, many products have become available on the market which have the appearance of a radiant barrier, but without low emissivity, and not functioning properly as thermal insulation. The objective of this study is to analyse the efficiency of some types of radiant barriers found on the civil construction market, as well as to analyse the efficiency of sheets made from the joining together of a solid urban waste, long-live carton packaging, *in loco* and in the laboratory. The *in loco* measurements were carried out in a roof of a residence in the city of Florianópolis, where the heat flux, surface temperatures of the tiles and the ceiling, and the internal and external temperatures, were monitored. The laboratory experiments were carried out with an apparatus which simulates the thermal resistances of a real roof. The results allowed the verification of which is the best type of radiant barrier, that is, which achieves the greatest reduction in heat flux through the roof. This study also allowed a comparison between the *in loco* and laboratory results.

08/02769 Evaluation of the absorption coefficient for solar radiation in sunspaces and windowed rooms

Oliveti, G. *et al. Solar Energy*, 2008, 82, (3), 212–219.
This paper proposes a simplified model for the evaluation of the solar energy absorbed by a sunspace using an effective absorption coefficient defined as the ratio of the solar energy absorbed by the internal surfaces of the room and the solar energy entering through the glazed surfaces. Reference is made to a simple geometries constituting volumes with glass surfaces of various sizes, number and orientation. In total 10 different geometrical configurations are considered. An extensive parametric analysis is carried out by means of a simulation code with the aim of highlighting the range of variability of the absorption coefficient and the most important variables on which it depends: the latitude, geometrical characteristics of the volume, type of glass, exposure and the optical properties of the opaque surfaces. The results obtained show that the absorption phenomenon can be very adequately parameterized using the simplified models that are proposed.

08/02770 High sintering ability and electrical conductivity of Zn doped $La(Ca)CrO_3$ based interconnect ceramics for SOFCs

Liu, M. *et al. Journal of Power Sources*, 2008, 177, (2), 451–456.
In order to improve the sintering ability of $La_{0.7}Ca_{0.3}CrO_{3-\delta}$ (LCC), which has been considered as the interconnect material for SOFC but needs rather high temperature to densification, the ceramic powder with a nominal composition of $La_{0.7}Ca_{0.3}Cr_{0.95}Zn_{0.05}O_{3-\delta}$ (LCCZ) was prepared by auto-ignition process. The result was quite positive, that the specimens made by pressing the powder under 360 MPa and sintered at 1200 °C in air for 5 h showed a relative density of 95.2%. The electrical conductivity of LCCZ sintered at 1400 °C for 5 h reached $47.5\,S\,cm^{-1}$ in air and $6.15\,S\,cm^{-1}$ in hydrogen at 800 °C, which were much higher than the values of LCC. The thermal expansion coefficient of LCCZ was $11.5 \times 10^{-6}\,K^{-1}$, which well matches other components of SOFC.

08/02771 Microstructure changes and properties of TiC-coated carbon fiber-reinforced carbon composites

Wang, K. *et al. Fusion Engineering and Design*, 2008, 83, (4), 644–648.
In the present paper, X-ray diffraction and X-ray photoelectron spectroscopy were used to study distortion of TiC crystals after thermal cycles in plasma environment. Scanning electron microscopy was used to observe morphology changes and penetrating cracks in TiC/C coatings. To avoid the cracks and enhance properties of coated carbon fibre-reinforced carbon (C/C) composites, TiC/C composites were prepared as buffer layer to relieve thermal stresses. Thermal cycles indicated that the buffer layer could effectively improve thermal shock resistance of pure TiC coated C/C composites. To study the reason, transmission electron microscopy results suggested that TiC particles were uniformly imbedded in pyrocarbon in the buffer layer, which was advantageous to relieve mismatch of coefficient of thermal expansion between pure TiC and C/C. Moreover, thermal conductivity tests showed that the buffer layer was in favour of transferring heat loading.

08/02772 Prontonic ceramic membrane fuel cells with layered $GdBaCo_2O_{5+x}$ cathode prepared by gel-casting and suspension spray

Lin, B. *et al. Journal of Power Sources*, 2008, 177, (2), 330–333.

In order to develop a simple and cost-effective route to fabricate protonic ceramic membrane fuel cells (PCMFCs) with layered $GdBaCo_2O_{5+x}$ (GBCO) cathode, a dense $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$ (BZCY7) electrolyte was fabricated on a porous anode by gel-casting and suspension spray. The porous NiO–$BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$ (NiO–BZCY7) anode was directly prepared from metal oxide (NiO, $BaCO_3$, ZrO_2, CeO_2 and Y_2O_3) by a simple gel-casting process. A suspension of $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$ powders synthesized by gel-casting was then employed to deposit $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$ (BZCY7) thin layer by pressurized spray process on NiO–BZCY7 anode. The bi-layer with 10 μm dense BZCY7 electrolyte was obtained by co-sintering at 1400 °C for 5 h. With layered GBCO cathode synthesized by gel-casting on the bi-layer, single cells were assembled and tested with H_2 as fuel and the static air as oxidant. An open-circuit potential of 0.98 V, a maximum power density of 266 $mW\,cm^{-2}$, and a low polarization resistance of the electrodes of 0.16 $\Omega\,cm^2$ was achieved at 700 °C.

08/02773 Single component and competitive adsorption of propane, carbon dioxide and butane on Vycor glass

Čermáková, J. Ř. *et al. Chemical Engineering Science*, 2008, 63, (6), 1586–1601.

Equilibrium of gas phase adsorption on Vycor glass has been investigated. Adsorption isotherms for propane, carbon dioxide and butane as pure gases, binary mixtures and ternary mixtures were determined experimentally as a function of temperature using a volumetric method. The single-component isotherms were described with the Langmuir and Freundlich equations. Additionally, a second order isotherm based on statistical thermodynamics and an isotherm equation based on vacancy solution theory taking into account real phase behaviour were used for fitting single-component equilibrium data. In order to describe the measured partial isotherms for binary mixtures, at first simple extensions of the single-component isotherm models were used, i.e. the conventional competitive Langmuir model and a multi-Freundlich equation based on the ideal adsorbed solution theory (IAS). Since these two simple isotherm models failed to represent the unusual competitive behaviour observed, three model extensions using additional mixture parameters were applied, i.e. two modified multi-Langmuir equations based on: (a) statistical thermodynamics and (b) vacancy solution theory and a modified multi-Freundlich IAS model correcting spreading pressure uncertainties. These three model equations were found to be capable to describe the observed behaviour better. Finally, the measured partial adsorption equilibrium data of the ternary system were correlated based on the extended equations using the determined additional binary parameters. The results obtained reveal the difficulty to predict accurately multi-component adsorption equilibria.

08/02774 Small recuperated ceramic microturbine demonstrator concept

McDonald, C. F. and Rodgers, C. *Applied Thermal Engineering*, 2008, 28, (1), 60–74.

It has been about a decade since microturbines first entered service in the distributed generation market, and the efficiencies of these turbogenerators rated in the 30–100 kW power range have remained essentially on the order of 30%. In this time frame the cost of fuel (natural gas and oil) has increased substantially, and efforts are now underway to increase the efficiency of microturbines to 40% or higher. Various near-term means of achieving this are underway by utilizing established gas turbine technology, but now based on more complex thermodynamic cycles. A longer-term approach of improving efficiency is proposed in this paper based on the retention of the basic recuperated Brayton cycle, but now operating at significantly higher levels of turbine inlet temperature. However, in small low pressure ratio recuperated microturbines embodying radial flow turbomachinery this necessitates the use of ceramic components, including the turbine, recuperator and combustor. A development approach is proposed to design, fabricate and test a 7.5 kW ceramic microturbine demonstrator concept, which for the first time would involve the coupling of a ceramic radial flow turbine, a ceramic combustor, and a compact ceramic fixed-boundary high effectiveness recuperator. In a period of some three years, the major objectives of the proposed small ceramic microturbine research and development effort would be to establish a technology base involving thermal and stress analysis, design methodology, ceramic component fabrication techniques, and component development, these culminating in the assembly and testing to demonstrate engine structural integrity, and to verify performance. This would provide a benchmark for more confidently advancing to increased size ceramic-based turbogenerators with the potential for efficiencies of over 40%. In addition, the power size of the tested prototype could possibly emerge as a viable product, namely as a natural gas-fired turbogenerator with the capability of meeting the total energy needs of an average house.

08/02775 Thermal investigation of fabricating porous NiTi SMA by SHS

Zhang, L. and Wang, Z. *Experimental Thermal and Fluid Science*, 2008, 32, (6), 1255–1263.

In this paper, the porous NiTi shape memory alloy fabricated by self-propagating high-temperature synthesis has been investigated experimentally and numerically. The mathematical models about the ignition and the sintering were constructed to investigate the effect of the preheating temperature and the coil temperature on the combustion. The results showed that the temperature difference between the ignition face and the bottom face was large due to low heat transfer conductivity. The ignition time would increase with the decrease of the coil temperature and the preheating temperature. The temperatures for different locations showed a strong dependence on the combustion time for lower preheating temperature, for the preheating temperature 1173 K, this mode of the combustion has transferred from SHS to thermal explosion. The transient partial molten phenomenon occurred during the process of combustion, which was more homogenous for preheating temperature 873 K. The mean velocity of the combustion wave was investigated systematically. An experiment was also carried out to investigate the ignition and SHS reaction for porous NiTi alloy in this paper. It was found that the results of experiment and numerical simulation were shown in good consistence.

08/02776 Thermotropic glass with active dimming control for solar shading and daylighting

Inoue, T. *et al. Energy and Buildings*, 2008, 40, (3), 385–393.

The effectiveness of an autonomous responsive dimming (thermotropic) glass panel fabricated with a transparent heating layer and an electrochromic layer to provide additional active dimming control is examined through preliminary experiments and simulations. Thermotropic glass consists of two panes of glass sandwiching a polymer gel that undergoes a transition from clear to cloudy at a threshold temperature. Winter temperatures can thus prevent the glass from dimming when required for solar shading. With appropriate control of the heating layer, however, the performance of the panel with respect to office solar-shading requirements is demonstrated to be superior to that without the heating layer, despite the simplicity of the system. The configuration requires relatively low electric power, utilizing solar radiation energy to maintain the cloudy state as required. In a different approach, application of electrochromic layer for active dimming control is proposed and verified in various aspects with wavelength characteristics considering simulation.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

08/02777 Artificial intelligence techniques for photovoltaic applications: a review

Mellit, A. and Kalogirou, S. A. *Progress in Energy and Combustion Science*, 2008, 34, (5), 574–632.

Artificial intelligence (AI) techniques are becoming useful as alternate approaches to conventional techniques or as components of integrated systems. They have been used to solve complicated practical problems in various areas and are becoming more popular nowadays. They can learn from examples, are fault tolerant in the sense that they are able to handle noisy and incomplete data, are able to deal with non-linear problems and once trained can perform prediction and generalization at high speed. AI-based systems are being developed and deployed worldwide in a wide variety of applications, mainly because of their symbolic reasoning, flexibility and explanation capabilities. AI has been used in different sectors, such as engineering, economics, medicine, military, marine, etc. They have also been applied for modelling, identification, optimization, prediction, forecasting and control of complex systems. The paper outlines an understanding of how AI systems operate by way of presenting a number of problems in photovoltaic systems application. Problems presented include three areas: forecasting and modelling of meteorological data, sizing of photovoltaic systems and modelling, simulation and control of photovoltaic systems. Published literature presented in this paper show the potential of AI as design tool in photovoltaic systems.

08/02778 Biofuel potential production from the Orbetello lagoon macroalgae: a comparison with sunflower feedstock

Bastianoni, S. *et al. Biomass and Bioenergy*, 2008, 32, (7), 619–628.

The diversification of different types and sources of biofuels has become an important energy issue in recent times. The aim of this work is to evaluate the use of two kinds of renewable feedstocks in order to produce biodiesel. The authors have analysed the potential production of oil from two species of macroalgae considered as waste coming out from a lagoon system involved in eutrophication and from sunflower seeds. Oil extraction yields of both feedstock have been tested. Furthermore, a comparison has been carried out based on the emergy approach, in order to evaluate the sustainability and environmental performance of both processes. The results show that, under present conditions, considering oil extraction yields, the production of oil from sunflower seeds is feasible, because of the lower value of transformity of the final product with respect to macroalgae. On the other hand, the results demonstrate that with improvements of oil extraction methodology, macroalgae could be considered a good residual biomass usable for biofuel production.

08/02779 Characterization of bio-oil obtained from fruit pulp pyrolysis

Özbay, N. *et al. Energy*, 2008, 33, (8), 1233–1240.

Apricot pulps was pyrolysed in a fixed-bed reactor under different pyrolysis conditions to determine the role of final temperature, sweeping gas flow rate and steam velocity on the product yields and liquid product composition with a heating rate of 5 °C/min. Final temperature range studied was between 300 and 700 °C and the highest liquid product yield was obtained at 550 °C. Liquid product yield increased significantly under nitrogen and steam atmospheres. For the optimum conditions, pyrolysis of peach pulp was furthermore studied. Liquid products obtained under the most suitable conditions were characterized by FTIR and ^{1}H-NMR. In addition, gas chromatography/mass spectrophotometer was achieved on all pyrolysis oils. Characterization showed that bio-oil could be a potential source for synthetic fuels and chemical feedstock.

08/02780 Entropy generation due to conjugate natural convection in enclosures bounded by vertical solid walls with different thicknesses

Varol, Y. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 648–658.

Entropy generation due to conjugate natural convection heat transfer and fluid flow has been studied inside an enclosure with bounded by two solid massive walls from vertical sides at different thicknesses. Enclosure is differentially heated from vertical walls and horizontal walls are adiabatic. Governing equations which are written in streamfunction-vorticity form solved by finite difference technique for the governing parameters as Rayleigh number, $10^3 \leq Ra \leq 10^6$, length ratio of solid walls as ε_1 (for left vertical wall) and ε_2 (for right vertical wall) and thermal conductivity ratio of solid to fluid (k), $1 \leq k \leq 10$. Entropy generation contours due to fluid friction and heat transfer irreversibility, isotherms, streamlines, Nusselt numbers and velocity profiles were obtained. It is found that entropy generation increases with increasing of thermal conductivity ratio and thicknesses of the walls. Entropy generation due to heat transfer is more significant than that of fluid flow irreversibility for all values of thickness of the solid vertical walls.

08/02781 Equilibrium modeling of global reduction reactions for a downdraft (biomass) gasifier

Sharma, A. K. *Energy Conversion and Management*, 2008, 49, (4), 832–842.

This article proposed a full equilibrium model of global reduction reactions for a downdraft biomass gasifier in order to predict the accurate distribution of various gas species, unconverted char and reaction temperature. Full equilibrium of the global reduction reactions has been described using thermodynamics principles based on the stoichiometric approach. Model predictions for equilibrium constants for reduction reactions and dry gas composition have been validated by comparing the data collected from various sources. Simulations modelling the influences of moisture content in feedstocks, pressure, equivalence ratio and initial temperature input on dry gas composition, unconverted char, calorific value of gas, gasification efficiency, outlet gas temperature and endothermic heat released in char bed. For optimal energy conversion of Douglas fir bark, the range of moisture content and equivalence ratio should be limited to 10–20% and 0.3–0.45 respectively, while the initial temperature in the reduction reaction zone should not be less than 1200 K. The accuracy of the prediction of the equilibrium model depends on the correctness of the initial conditions of temperature and reactants concentrations.

08/02782 Ethanol from eel grass via steam explosion and enzymatic hydrolysis

Viola, E. *et al. Biomass and Bioenergy*, 2008, 32, (7), 613–618.

Zostera marina was investigated for ethanol production. The examined plant contained 30% of glucan. It was pretreated by steam explosion and the best conditions were assessed by a 2^3 full factorial design with repeated centre point. Temperature, time of pretreatment and oxalic acid load were selected as experimental factors. The experimental data of water-soluble sugar recovery and enzymatic saccharification of the insoluble residue were analysed by the response surface regression procedure, which provided significant models with $R^2 = 0.98$. The best results (5.06 g of soluble sugars and 52.9 g of glucose, respectively, from 100 g of exploded material and 100 g of insoluble fibre) were attained at pretreatment of 180 °C, 300 s and 2 wt% of oxalic acid. Fermentation tests of the hydrolysed fibre were carried out and the ethanol production was optimized by varying the enzyme load, the amount of yeast and the solid concentration. In the best cases 243 g of ethanol was produced per kg of Zostera fibre and the concentration of 4.7 v% was attained in tests of high-solid load.

08/02783 Hydrogen production from allothermal biomass gasification by means of palladium membranes

Karellas, S. *et al. Fuel Processing Technology*, 2008, 89, (6), 582–588.

One of the most promising technologies for the production of hydrogen is the use of a palladium membrane in order to separate hydrogen from a gas mixture coming from the allothermal biomass gasification process. At the authors' institution (TU München), an innovative allothermal gasifier called biomass heat pipe reformer has been developed. This gasifier produces a hydrogen-rich gas which can be further used for energy production. A palladium membrane can be installed in the gasifier in order to gain pure hydrogen from this gas mixture. This gas can be then used in applications that demand high purified hydrogen, for example polymer electrolyte membrane fuel cells. The present paper describes the aforementioned gasification technology combined with a palladium filter and investigates the results from the simulation of these systems.

08/02784 Importance of biomass energy sources for Turkey

Demirbas, A. *Energy Policy*, 2008, 36, (2), 834–842.

Various agricultural residues such as grain dust, crop residues and fruit tree residues are available in Turkey as the sources of biomass energy. Among the biomass energy sources, fuelwood seems to be one of the most interesting because its share of the total energy production of Turkey is high at 21% and the techniques for converting it to useful energy are not necessarily sophisticated. Selection of a particular biomass for energy requirements is influenced by its availability, source and transportation cost, competing uses and prevalent fossil fuel prices. Utilization of biomass is a very attractive energy resource, particularly for developing countries since biomass uses local feedstocks and labour. Like many developing countries, Turkey relies on biomass to provide much of its energy requirement. More efficient use of biomass in producing energy, both electrical and thermal, may allow Turkey to reduce petroleum imports, thus affecting its balance of payments dramatically. Turkey has always been one of the major agricultural countries in the world. The importance of agriculture is increasing due to biomass energy being one of the major resources in Turkey. Biomass waste materials can be used in Turkey to provide centralized, medium- and large-scale production of process heat for electricity production. Turkey's first biomass power project is under development in Adana province, at an installed capacity of 45 MW. Two others, at a total capacity of 30 MW, are at the feasibility study stage in Mersin and Tarsus provinces. Electricity production from biomass has been found to be a promising method in the nearest future in Turkey.

08/02785 Influence of biomass burning on wintertime fine particulate matter: source contribution at a valley site in rural British Columbia

Jeong, C.-H. *et al. Atmospheric Environment*, 2008, 42, (16), 3684–3699.

Particulate matter (PM) speciation data were collected between November 2004 and August 2006 in the rural valley area of British Columbia, Canada. Source apportionment of PM was performed using a receptor model, positive matrix factorization (PMF), to identify possible sources of PM and determine the influence of each identified source on local air quality. High concentrations of PM$_{2.5}$ ($<2.5\,\mu$m) were observed in winter months with an average of 18 μg m^{-3}, while the average concentration in summer months was approximately 6 μg m^{-3}. PMF apportioned the PM$_{2.5}$ mass into seven factors identified as Na-rich, secondary sulfate, wood burning, wood processing, crustal material, traffic, and winter heating. The most important sources affecting ambient air quality in the deep valley rural area were wood burning and winter heating factors. In winter the wood burning and winter heating sources accounted for approximately 31% and 43% of the total PM$_{2.5}$ mass, respectively, indicating the significant influence of biomass burning in the rural area. The wood burning and winter heating factors were highly associated with high organic carbon and volatile organic compounds. The identity of the sources was further elucidated by exploring their relationship with other measured parameters; a correlation study was conducted to evaluate relationships between the sources, gaseous pollutants, and meteorological variables.

08/02786 Investigation of the potential of agro-industrial material as low cost substrate for ethanol production by using *Candida tropicalis* and *Zymomonas mobilis*

Patle, S. and Lal, B. *Biomass and Bioenergy*, 2008, 32, (7), 596–602.

Ethanol production from agro-industrial waste (thippi) was analysed as low-cost feedstock using mixed culture fermentation. Reducing sugars yield by acid hydrolysis was 395.2 g kg^{-1} thippi and ethanol yield was 35.8 g kg^{-1} thippi. However, reducing sugars in enzyme hydrolysis was 535.33 g kg^{-1} thippi, which resulted in 254.45 g ethanol yield kg^{-1} thippi (72.8 g l^{-1}, using mixed culture), revealed 93.18% of the theoretical yield of ethanol. *Zymomonas mobilis* alone yielded 228.55 g ethanol kg^{-1} thippi (65.3 g l^{-1}), which is 82.83% of the theoretical yield and *Candida tropicalis* alone yielded 214.2 g ethanol kg^{-1} thippi (61.2 g ethanol l^{-1}), reaching more than the published value for *C. tropicalis* with starch. This is 76.58% of the theoretical yield. These data are of 1 l fermentor. Ethanol fermentation from thippi hydrolysate was then scaled up to 10 l fermentor; ethanol yield was 219.63 g kg^{-1} thippi, which was 78.82% of the theoretical yield.

08/02787 Overview of recent developments in sustainable biomass certification

van Dam, J. *et al. Biomass and Bioenergy*, 2008, 32, (8), 749–780.

The objective of this paper is to give a comprehensive review of initiatives on biomass certification from different viewpoints of stakeholders, including national governments (such as The Netherlands, the UK, Belgium and Germany), the European Commission, non-governmental organizations, companies, and international bodies up until October 2007. Furthermore, opportunities and restrictions in the development of biomass certification are described, including international trade law limitations, lack of adequate methodologies, stakeholder involvement requirements and certification costs. Next, five different approaches for the implementation of a biomass certification system are compared and discussed. Main differences are the voluntary or mandatory character and the geographical extent of the proposed strategies in terms of biomass end-use. It is concluded that criteria to ensure the sustainable production of biomass are needed urgently. To some extent criteria categories can be covered using existing systems, but others (such as greenhouse gases and energy balances, changing land-use) require the development of new methodologies. A gradual development of certification systems with learning (through pilot studies and research) and expansion over time, linked to the development of advanced methodologies can provide valuable experience, and further improve the feasibility and reliability of biomass certification systems. However, better international coordination between initiatives is required to improve coherence and efficiency in the development of sustainable biomass certification systems, to avoid the proliferation of standards and to provide a clearer direction in the approach to be taken. Finally, next to certification, alternative policy tools should be considered as well to ensure sustainable biomass production.

08/02788 Pre-treatment technologies, and their effect on international bioenergy supply chain logistics. Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation

Uslu, A. *et al. Energy*, 2008, 33, (8), 1206–1223.

The pre-treatment step has a significant influence on the performance of bioenergy chains, especially on logistics. Torrefaction, pelletization and pyrolysis technologies can convert biomass at modest scales into dense energy carriers that ease transportation and handling. Torrefaction is a very promising technology due to its high process efficiency (94%) compared to pelletization (84%) and pyrolysis (64%). When torrefaction is combined with pelletization, the product (TOP) energy content is as high as 20.4–22.7 GJ/ton. The primary energy requirement for TOP delivery from Latin America to Rotterdam harbour can be as low as 0.05 GJ/GJ, in contrast to 0.12 GJ/GJ for pellets and 0.08 GJ/GJ_{HHV} for pyrolysis oil. TOP can be delivered to Europe at over 74 €/ton (3.3 €/GJ) and electricity could be produced as cheap as 4.4 €cent/kWh_e from an existing co-firing plant. Fisher Tropisch fuel costs 6 €/GJ_{HHV} for TOP, 7 €/GJ for conventional pellets and 9.5 €/GJ_{HHV} for pyrolysis oil. Consequently, fuel production from TOP and conventional pellets is comparable to the current gasoline production cost ranging from 3 to 7 €/GJ_{HHV} and diesel from 2 to 7 €/GJ_{HHV}, depending on the oil market. Thus, well designed supply chains make international trade of biomass feasible from energy efficiency and economic perspective.

08/02789 Progress in bioethanol processing

Balat, M. *et al. Progress in Energy and Combustion Science*, 2008, 34, (5), 551–573.

Production of ethanol (bioethanol) from biomass is one way to reduce both consumption of crude oil and environmental pollution. Bioethanol is appropriate for the mixed fuel in the gasoline engine because of its high octane number, and its low cetane number and high heat of vaporization impede self-ignition in the diesel engine. So, ignition improver, glow-plug, surface ignition, and pilot injection are applied to promote self-ignition by using diesel-bioethanol-blended fuel. Disadvantages of bioethanol include its lower energy density than gasoline, its corrosiveness, low flame luminosity, lower vapour pressure (making cold starts difficult), miscibility with water, and toxicity to ecosystems. Bioethanol can be produced from cellulosic feedstocks. One major problem with bioethanol production is the availability of raw materials for the production. The availability of feedstocks for bioethanol can vary considerably from season to season and depends on geographic locations. Lignocellulosic biomass is the most promising feedstock considering its great availability and low cost, but the large-scale commercial production of fuel bioethanol from lignocellulosic materials has still not been implemented. Conversion technologies for producing bioethanol from cellulosic biomass resources such as forest materials, agricultural residues and urban wastes are under development and have not yet been demonstrated commercially. For designing fuel bioethanol production processes, assessment of utilization of different feedstocks (i.e. sucrose containing, starchy materials, lignocellulosic biomass) is required considering the big share of raw materials in bioethanol costs. In this work a review of the biological and thermochemical methods that could be used to produce bioethanol is made and an analysis of its global production trends is carried out.

08/02790 Screening boreal energy crops and crop residues for methane biofuel production

Lehtomäki, A. *et al. Biomass and Bioenergy*, 2008, 32, (6), 541–550.

The purpose of the study was to screen potential boreal energy crops and crop residues for their suitability in methane production and to investigate the effect of harvest time on the methane production potential of different crops. The specific methane yields of crops, determined in 100–200 d methane potential assays, varied from 0.17 to 0.49 m^3 CH_4 kg^{-1} VS_{added} (volatile solids added) and from 25 to 260 m^3 CH_4 $t_{ww}{}^{-1}$ (tonnes of wet weight). Jerusalem artichoke, timothy-clover grass and reed canary grass gave the highest potential methane yields of 2900–5400 m^3 CH_4 ha^{-1}, corresponding to a gross energy yield of 28–53 MWh ha^{-1} and ca. 40,000–60,000 km ha^{-1} in passenger car transport. The effect of harvest time on specific methane yields per VS of crops varied a lot, whereas the specific methane yields per t_{ww} increased with most crops as the crops matured.

08/02791 Size and structural characterization of lignin-cellulosic fuels after the rapid devolatilization

Biagini, E. *et al. Fuel*, 2008, 87, (2), 177–186.

The aim of this work is to develop and test a method for assessing the size and the morphology of biomass fuels and their chars. Severe thermal conditions (high temperature and heating rate) are programmed during the pyrolysis, focusing on characteristics of chars in combustion or gasification. An image analysis program is used to quantitatively study several scanning electron microscopy images of fuel and char samples. Distributions of results are obtained for a significant number of particles from a statistical point of view. Average values and the standard deviations of the distributions quantify the heterogeneous nature of the fuel and char particles, providing useful parameters for advanced modelling. Size, shape factors (aspect and roundness) and superficial parameters are defined and measured (or calculated) developing a procedure for a low time-consuming analysis. The structural variations caused by the fast release of a high amount of volatile products are evaluated comparing the results obtained on fuel and char particles. The results are discussed to assessing the suitability of the selected parameters and the possibility to quantify softening, melting, shrinking and fragmentation phenomena. The method is applied to two biomass fuels of different origin and chemical composition: wood pellets and olive residue.

08/02792 The emerging liquid biofuel market in Argentina: implications for domestic demand and international trade

Lamers, P. *et al. Energy Policy*, 2008, 36, (4), 1479–1490.

While the world's transport energy matrix is still strongly linked to limited and heavily polluting fossil fuels, new markets are appearing for the production and use of alternative transport fuels, such as liquid biofuels. Due to an interconnected global economy, such markets today are developing on a global scale with actors looking to meet local as well as potential international demand. The aim of this paper is to describe and evaluate the emergence of markets for liquid biofuels in Argentina. It reveals that biodiesel production for international supply is likely to emerge in the short run (up to 2010), giving the opportunity to be switched back to local supply in the medium run (post-2010). It also suggests that a bioethanol market (demand and supply) does not seem to be likely in the short run, and it is highly uncertain in the medium run as the most influential actors oppose its development. On the other hand, the current constellations of the biodiesel market appear to leave many uncertainties regarding its sustainability, especially in regard to a limited role of small and medium sized enterprises, and a suitable and diversified biodiesel feedstock. Currently, the focus lies solely on (very) large-scale production of biodiesel derived from soybean oil for the export market.

08/02793 Thermal behaviour of solar air heater with compound parabolic concentrator

Tchinda, R. *Energy Conversion and Management*, 2008, 49, (4), 529–540.

A mathematical model for computing the thermal performance of an air heater with a truncated compound parabolic concentrator having a flat one-sided absorber is presented. A computer code that employs an iterative solution procedure is constructed to solve the governing energy equations and to estimate the performance parameters of the collector. The effects of the air mass flow rate, the wind speed and the collector length on the thermal performance of the present air heater are investigated. Predictions for the performance of the solar heater also exhibit reasonable agreement, with experimental data with an average error of 7%.

08/02794 Towards a sustainably certifiable futures contract for biofuels

Mathews, J. A. *Energy Policy*, 2008, 36, (5), 1577–1583.

How are biofuels to be certified as produced in a sustainable and responsible fashion? In the global debate over this issue, one party to the proceedings seems rarely to be mentioned – namely the commodities exchanges through which a global biofuels market is being created. In this contribution, a solution is proposed to the problem of sustainability certification through a biofuels futures contract equipped with 'proof of origin' documentation. The proposal does not call for any radical break with current practice, extending existing certification procedures with a requirement for the vendor to provide documentation, probably in barcoded form, of the history of the biofuel offered for sale, including plantation and biorefinery where the biofuel was produced and subsequent blendings it may have undergone. The proposal is thus compatible with the blending practices of large global traders, whose activities are the source of the difficulties of other approaches to certification. It is argued that if such a sustainable futures contract for bioethanol (in the first instance) were to be introduced, then it would likely trade at a premium and become the primary vehicle for North–South trade in biofuels.

08/02795 Transesterification of soybean oil to biodiesel using CaO as a solid base catalyst

Liu, X. *et al. Fuel*, 2008, 87, (2), 216–221.

In this study, transesterification of soybean oil to biodiesel using CaO as a solid base catalyst was studied. The reaction mechanism was proposed and the separate effects of the molar ratio of methanol to oil, reaction temperature, mass ratio of catalyst to oil and water content were investigated. The experimental results showed that a 12:1 molar ratio of methanol to oil, addition of 8% CaO catalyst, 65 °C reaction temperature and 2.03% water content in methanol gave the best results, and the biodiesel yield exceeded 95% at 3 h. The catalyst lifetime was longer than that of calcined $K_2CO_3/\gamma\text{-}Al_2O_3$ and $KF/\gamma\text{-}Al_2O_3$ catalysts. CaO maintained sustained activity even after being repeatedly used for 20 cycles and the biodiesel yield at 1.5 h was not affected much in the repeated experiments.

Geothermal energy

08/02796 Economy of exploiting heat from low-temperature geothermal sources using a heat pump

Kulcar, B. *et al. Energy and Buildings*, 2008, 40, (3), 323–329.

The article describes the economy of exploiting heat from low-temperature geothermal sources for high-temperature heating of buildings using a heat pump. For the exploitation of low-temperature geothermal sources, a two stage heat pump with a heat exchanger was planned. The pump consists of two single stage heat pumps which use different refrigerants at each stage. At stage 1, the calculation of the heat pump is conducted with refrigerant R407c; at stage 2 of the heat pump, the refrigerant R600a is used. The main operational characteristics of a two stage heat pump are presented in the form of diagrams. For the exploitation of heat from geothermal water with a temperature of 45 °C, a profitability evaluation of the investment in the heat pump was carried out, using the method of the net present value. In the research, also the coefficient of profitability and the period of time in which the investment is going to return itself were established.

08/02797 Prediction of enthalpy production from fractured geothermal reservoirs using partitioning tracers

Wu, X. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (5–6), 1453–1466.

The goal of geothermal reservoir management is to economically recover as much energy as possible from the reservoir. This paper presents the development of improved techniques for monitoring and predicting two-phase mass and heat transport in fractures. Partitioning tracers can yield valuable, early information about fracture properties used within a semi-analytical approach for calculating enthalpy production from the fractured system. This is demonstrated for a synthetic model with a fracture network. The comparisons of the semi-analytical solutions with the simulation results show that the model predicts enthalpy production is easy, fast and ideally suited for sensitivity studies.

08/02798 Study of damage and repair of blades of a 300 kW wind turbine

Marín, J. C. *et al. Energy*, 2008, 33, (7), 1068–1083.

The inspection of damages detected in some blades of 300 kW wind turbines revealed that the nature of these damages was probably due to a fatigue mechanism. The causes that had originated the failure (superficial cracks, geometric concentrator, abrupt change of thickness) have been studied, verifying, by means of the simplified evaluation procedure of fatigue life of the 'Germanischer Lloyd' (GL) standard, that these causes can explain the failure detected in the period of time in which it happened. A suitable configuration for the repair of the damaged blades has been studied, by means of a finite element model. The proposed modifications repair the cracks and in addition contribute to relaxing the stress state in the affected zone. The introduction of a triangular reinforcement, which smoothes the re-entrant corner existing in the original design, incorporating a laminate of reinforcement, produces a significant decrease in the stress level in the damaged zone of the blades.

Solar energy

08/02799 A control procedure for the elimination of mal flow rate distribution in evaporating flow in parallel pipes

Taitel, Y. *et al. Solar Energy*, 2008, 82, (4), 329–335.

Solar power plants that are based on an array of parallel parabolic trough solar collectors currently use oil as the heated fluid. Direct steam generation (DSG) has the potential of being a more efficient and less costly process owing to the elimination of oil as an indirect secondary heating medium and the elimination of heat exchanges and extra equipment needed for the transfer of heat from oil to water/steam. Unfortunately the use of DSG may possess problems regarding undesired flow distribution among the parallel pipes as well as possible flow instabilities. In this work, a control procedure is proposed that can adjust the flow rate in each of the parallel pipes to a desired quality at the pipes exit.

08/02800 A highly efficient novel azimuthal heliotrope

Mavromatakis, F. and Franghiadakis, Y. *Solar Energy*, 2008, 82, (4), 336–342.

A new type of a single-axis azimuthal tracker is presented. The novel feature of this tracker is the ability to move the collector's plane in two directions through a special support structure. This structure consists of a sliding mechanism on the central axis and a curved window on the cylindrical surface coaxial to the central axis. Consequently, the proposed novel heliotrope behaves similarly to a two-axis tracker. Two different windows designed on the cylindrical surface may be used to provide very high efficiencies throughout a year. Several performance measurements have been conducted on this novel tracker, a polar tracker and the reference two-axis tracker. Pyranometers, appropriately calibrated, were installed on all three systems to record the global incoming irradiance on the collector's plane. It is shown that the new tracker system can be very efficient since its plane intercepts, at least, 98% of the insolation with respect to a two-axis tracker. The proposed system can be utilized in solar-related applications (photovoltaic or thermal).

08/02801 A novel maximum power point tracking for photovoltaic applications under partially shaded insolation conditions

Ahmed, N. A. and Miyatake, M. *Electric Power Systems Research*, 2008, 78, (5), 777–784.

In this paper, a novel strategy of maximum power point tracking is presented for photovoltaic power generation systems based on Fibonacci search algorithm to realize simple control system to track the real maximum power point even under non-uniform or for rapidly changing insolation conditions. The Fibonacci search technique was modified in order to apply to time-variant P–V characteristics of the PV array. It is proved experimentally and through simulation results that the algorithm has good performances and very fast response even for partial shaded PV modules. The proposed technique can be applied to various types of PV power conditioners including dc–dc and dc–ac converters. It can be commonly used instead of the conventional MPPT techniques. This method requires neither the measurement of temperature and insolation level nor prior knowledge about the model of the used photovoltaic panel. The proposed method can track the global maximum power point in most cases by doing a wide-range search and more power can be extracted with partial shaded PV modules as compared to the other methods. Simulation and experimental results are presented to prove the feasibility of the proposed technique.

08/02802 An analysis of thermal and solar zone radiation models using an Angstrom–Prescott equation and artificial neural networks

Wan, K. K. W. *et al. Energy*, 2008, 33, (7), 1115–1127.

The correlation between the clearness index and sunshine duration is useful in the estimation of the solar radiation for areas where measured solar radiation data are unavailable. Regression techniques and artificial neural networks were used to investigate the correlations between daily global solar radiation and sunshine duration for different climates in China. Measurements made during the 30-year period (1971–2000) from 41 measuring stations covering nine thermal and seven solar climate zones and sub-zones across China were gathered and analysed. The performance of the regression and the ANN models in the thermal and solar zones was analysed and compared. The coefficient of determination (R^2), Nash–Sutcliffe efficiency coefficient, mean bias error (MBE) and root-mean-square error (RMSE) were determined. It was found that the regression models in both the thermal and the solar climate zones showed a strong correlation between the clearness index and sunshine duration ($R^2 = 0.79$–88). There appeared to be an increasing trend of larger MBE and RMSE from colder climates in the north to warmer climates in the south. In terms of the thermal and solar climate zone models, there was very little to choose between the two models.

08/02803 An evaluation on thermal performance of CPC solar collector

Kim, Y. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (4), 446–457.

The main objective of this work is the investigation and improvement of thermal performance of evacuated compound parabolic concentrator (CPC) solar collector with a cylindrical absorber. Modified types of this solar collector are always combined with the evacuated glass envelop or tracking system. The conventional stationary CPC solar collector has been compared with the single axis tracking CPC solar collector in outlet temperature, net heat flux onto the absorber and thermal efficiency. Numerical model has been analysed based on the irradiation determined actually and the results have been calculated to predict the thermal efficiency. Based on the comparison of the measured and calculated results, it is concluded that the numerical model can accurately estimate the performance of solar collectors. The result shows the thermal efficiency of the tracking CPC solar collector is more stable and about 14.9% higher than that of the stationary CPC solar collector.

08/02804 An experimental study on energy generation with a photovoltaic (PV)–solar thermal hybrid system

Erdil, E. *et al. Energy*, 2008, 33, (8), 1241–1245.

A hybrid system, composed of a photovoltaic (PV) module and a solar thermal collector is constructed and tested for energy collection at a geographic location of Cyprus. Normally, it is required to install a PV system occupying an area of about 10 m^2 in order to produce electrical energy; 7 kWh/day, required by a typical household. In this experimental study, only two PV modules were used of area approximately 0.6 m^2 (i.e. $1.3 \times 0.47\,\mathrm{m}^2$) each. PV modules absorb a considerable amount of solar radiation that generate undesirable heat. This thermal energy, however, may be utilized in water pre-heating applications. The proposed hybrid system produces about 2.8 kWh thermal energy daily. Various attachments that are placed over the hybrid modules lead to a total of 11.5% loss in electrical energy generation. This loss, however, represents only 1% of the 7 kWh energy that is consumed by a typical household in northern Cyprus. The pay-back period for the modification is less than 2 years. The low investment cost and the relatively short pay-back period make this hybrid system economically attractive.

08/02805 Breaking the cycle: producer and consumer perspectives on the non-adoption of passive solar housing in the US

Garrett, V. and Koontz, T. M. *Energy Policy*, 2008, 36, (4), 1551–1566.

Creating the technologies to solve the energy and pollution problems is only one part of the solution. Getting the technologies adopted may be a larger hurdle. This study examines the adoption of a low- or no-cost technology, passive solar housing design, in the United States. Interviews with professionals involved in passive solar supply identified lack of demand as the most important factor, followed by availability, awareness, and economic incentives. Corresponding survey results from homebuyers in one region suggest that lack of demand represents not disinterest, but rather lack of availability when purchasing a home. Conventional homeowners are not familiar with passive solar design, but are predisposed to favour it, especially if it can be incorporated into traditional housing styles. In addition, to the extent that they can learn information to counter the perceptions that passive solar homes are too complicated or there is too little sun in their region, homebuyers would be more willing to purchase a passive solar home. Policy interventions to promote passive solar homes should focus on supply-side incentives as well as information for homebuyers.

08/02806 Comparison of receivers for solar dish collector system

Kumar, N. S. and Reddy, K. S. *Energy Conversion and Management*, 2008, 49, (4), 812–819.

In this paper, a numerical investigation is performed to study the natural convective heat loss from three types of receivers for a fuzzy focal solar dish concentrator, namely cavity receiver, semi-cavity receiver and modified cavity receiver. The natural convection heat loss from the receivers is estimated by varying the inclination from 0° (cavity aperture facing sideways) to 90° (cavity aperture facing down). The orientation and geometry of the receiver strongly affect the natural convection heat loss. A comparative study is performed to predict the natural convection heat loss from the cavity, semi-cavity and modified cavity receivers. The convection heat loss is high at 0° and decreases monotonically with increase in angle up to 90° in all three cases. The convection heat losses at 0° and 90° inclination of the modified cavity receiver are 26.03% and 25.42% of the convection heat loss of the cavity receiver, respectively. The influence of area ratio (Aw/A_1) on the convective heat loss is investigated for the modified cavity receiver, and an optimum Aw/A_1 of eight is found for minimum natural convection heat loss. Among the three receivers, the modified cavity receiver is the preferred receiver for a fuzzy focal solar dish collector system.

08/02807 Design, development and performance monitoring of a photovoltaic-thermal (PVT) air collector

Aste, N. *et al. Renewable Energy*, 2008, 33, (5), 914–927.

The photovoltaic-thermal (PVT) systems allow the enhancement of the energy performance of photovoltaics, by removing thermal energy and subsequently decreasing the operating temperature of the cells. The possibility of the utilization of heat for climatization makes them attractive for the building integration. In order to diffuse this kind of solar systems it is necessary to translate the basic concepts into efficient and functional technological components and associated performance should be evaluated in a reliable manner. This paper presents the experimental and theoretical results of a research and development program carried out at the Politecnico di Milano on the design, development and performance monitoring of a hybrid PVT air collector. One of the main products of the research consists of a simulation model for performance prediction of the system. This research and development program led to the development of the 'tetto integrale solarizzato' (TIS) (i.e. integrated solar roof), an innovative technological system for building integration of hybrid PVT air collectors. The successful commercial application of the TIS in a research centre building is also shown as a case study.

08/02808 Experimental energy and exergy analysis of a double-flow solar air heater having different obstacles on absorber plates

Esen, H. *Building and Environment*, 2008, 43, (6), 1046–1054.

This paper presents an experimental energy and exergy analysis for a novel flat plate solar air heater (SAH) with several obstacles and without obstacles. For increasing the available heat-transfer area may be achieved if air is flowing simultaneously and separately over and under the different obstacle absorbing plates, instead of only flowing either over or under the different obstacle absorbing plates, leading to improved collector efficiency. The measured parameters were the inlet and outlet temperatures, the absorbing plate temperatures, the ambient temperature, and the solar radiation. Further, the measurements were performed at different values of mass flow rate of air and different levels of absorbing plates in flow channel duct. After the analysis of the results, the optimal value of efficiency is middle level of absorbing plate in flow channel duct for all operating conditions and the double-flow collector supplied with obstacles appears significantly better than that without obstacles. At the end of this study, the exergy relations are delivered for different SAHs. The results show that the largest irreversibility is occurring at the flat plate (without obstacles) collector in which collector efficiency is smallest.

08/02809 Experimental study of a double exposure solar cooker with finned cooking vessel

Harmim, A. *et al. Solar Energy*, 2008, 82, (4), 287–289.

A comparative experimental study of a box type solar cooker with two different cooking vessels was conducted, the first one conventional and the second one identical to the first in shape and volume but its external lateral surface provided with fins. Fins are shown to improve the heat transfer from the internal hot air of the cooker towards the interior of the vessel where the food to be cooked is placed. This reduces the cooking time considerably. The tests were carried out on the experimental platform of the Research Unit in Renewable Energies in Saharan Medium of Adrar, located at 27°53′N latitude and 0°17′W longitude in the Algerian Sahara.

08/02810 Heat transfer and friction factor correlations for a duct having dimple-shape artificial roughness for solar air heaters

Saini, R. P. and Verma, J. *Energy*, 2008, 33, (8), 1277–1287.

The heat transfer coefficient between the absorber plate and air can be considerably increased by using artificial roughness on the underside of the absorber plate of a solar air heater duct. Under the present work, an experimental study has been carried out to investigate the effect of roughness and operating parameters on heat transfer and friction factor in a roughened duct provided with dimple-shape roughness geometry. The investigation has covered the range of Reynolds number (Re) from 2000 to 12,000, relative roughness height (e/D) from 0.018 to 0.037 and relative pitch (p/e) from 8 to 12. Based on the experimental data, values of Nusselt number (Nu) and friction factor (f_r) have been determined for different values of roughness and operating parameters. In order to determine the enhancement in heat transfer and increment in friction factor values of Nusselt number and friction factor have been compared with those of smooth duct under similar flow conditions. Correlations for Nusselt number and friction factor have been developed for solar air heater duct provided such artificial roughness geometry.

08/02811 Heat transfer in inclined rectangular receivers for concentrated solar radiation

Muftuoglu, A. and Bilgen, E. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 551–556.

In this paper, heat transfer in inclined rectangular cavities is studied, which may be used as receivers of concentrated solar radiation. One of the active walls is subject to concentrated solar radiation and the other is kept at constant temperature. Continuity, momentum and energy equations are solved by finite difference – control volume numerical method. The relevant governing parameters are: the Rayleigh numbers from 10^3 to10^{12}, the cavity aspect ratio, $A = L/H$ from 0.5 to 2, the inclination angle, ϕ from 30 to 90°. It is found that the Nusselt number is an increasing function of the Rayleigh number, the aspect ratio and the inclination angle. Based on the computed data a correlation is derived in the form of $Nu = f(Ra, A, \phi)$.

08/02812 Impact of solar energy cost on water production cost of seawater desalination plants in Egypt

Lamei, A. *et al. Energy Policy*, 2008, 36, (5), 1748–1756.

Many countries in North Africa and the Middle East are experiencing localized water shortages and are now using desalination technologies with either reverse osmosis (RO) or thermal desalination to overcome part of this shortage. Desalination is performed using electricity, mostly generated from fossil fuels with associated greenhouse gas emissions. Increased fuel prices and concern over climate change are causing a push to shift to alternative sources of energy, such as solar energy, since solar radiation is abundant in this region all year round. This paper presents unit production costs and energy costs for 21 RO desalination plants in the region. An equation is proposed to estimate the unit production costs of RO desalination plants as a function of plant capacity, price of energy and specific energy consumption. This equation is used to calculate unit production costs for desalinated water using photovoltaic (PV) solar energy based on current and future PV module prices. Multiple PV cells are connected together to form a module or a panel. Unit production costs of desalination plants using solar energy are compared with conventionally generated electricity considering different prices for electricity. The paper presents prices for both PV and solar thermal energy. The paper discusses at which electricity price solar energy can be considered economical to be used for RO desalination; this is independent of RO plant capacity. For countries with electricity prices of 0.09 US$/kWh, solar-generated electricity (using PV) can be competitive starting from 2 US$/$W_p$ (W_p is the number of Watts output under standard conditions of sunlight). For Egypt (price of 0.06 US$/kWh), solar-generated electricity starts to be competitive from 1 US$/$W_p$. Solar energy is not cost competitive at the moment (at a current module price for PV systems including installation of 8 US$/$W_p$), but advances in the technology will continue to drive the prices down, whilst penalties on usage of fossil fuel will increase electricity costs from conventional non-renewable sources. Solar thermal is cheaper (at a current price of 0.06 US$/kWh) than PV; however, PV is more appropriate for Egypt (for the time being) as it is more applicable to the smaller RO plant sizes found in Egypt (up to 5 MW; 10,000–15,000 m^3/d product water capacity). It is expected that there will be a shift towards more centralized RO plants (larger size) in Egypt, to tackle the increasing water shortage, and this would then favour the adoption of solar thermal energy in the near future.

08/02813 Internal quantum efficiency for solar cells

Yang, W. J. *et al. Solar Energy*, 2008, 82, (2), 106–110.

The total internal quantum efficiency (IQE) of a flat-band p–n homojunction silicon solar cell and contributions of the three regions to it are numerically evaluated. It is found that both the spatial widths of the cell and the surface recombination velocities have significant impacts on the IQEs. By a linear transformation and a proper approximation, the differential equation of the minority carrier density in a textured cell becomes the same form as for the flat cell. What makes differences is that texturization slightly enhances the IQEs for photons with longer wavelengths while notably increasing external quantum efficiency. Hence it plays a good role for getting a better performance of a solar cell. It is considered that the results in the present are of universal technical importance both in designing solar cells and their surface structures.

08/02814 New control approach for a PV-diesel autonomous power system

Rashed, M. *et al. Electric Power Systems Research*, 2008, 78, (6), 949–956.

A new control scheme for the hybrid photovoltaic-diesel single-phase autonomous power system is proposed. The main advantage of this scheme is that the voltage control is accomplished by the interface inverter without need to the automatic voltage regulator of the diesel-driven generator. Unlike three-phase systems, frequency and voltage control in single-phase autonomous power systems imposes additional complexity. This is due to the pulsating nature of the single-phase loads instantaneous power at twice the rated frequency that may degrade the control efficacy. This obstacle is addressed in this paper and a new scheme is presented. The approach includes three control loops for maximum power tracking, voltage control and frequency control. The generator field current is held constant at its nominal value avoiding the saturation in the field circuit. A robust fuzzy logic controller is adopted for the speed control loop of the diesel engine. The dynamic performance of the system is investigated under different operating conditions.

08/02815 Numerical and experimental analysis of a salt gradient solar pond performance with or without reflective covered surface

Bezir, N. Ç. *et al. Applied Energy*, 2008, 85, (11), 1102–1112.

An experimental salt gradient solar pond having a surface area of $3.5 \times 3.5\,m^2$ and depth of 2 m has been built. Two covers, which are collapsible, have been used for reducing the thermal energy loses from the surface of the solar pond during the night and increasing the thermal efficiency of the pond solar energy harvesting during daytime. These covers having reflective properties can be rotated between 0° and 180° by an electric motor and they can be fixed at any angle automatically. A mathematical formulation that calculates the amount of the solar energy harvested by the covers has been developed and it is adapted into a mathematical model capable of giving the temporal temperature variation at any point inside or outside the pond at any time. From these calculations, hourly air and daily soil temperature values calculated from analytical functions are used. These analytic functions are derived by using the average hourly and daily temperature values for air and soil data obtained from the local meteorological station in Isparta region. The computational modelling has been carried out for the determination of the performance of insulated and uninsulated solar ponds having different sizes with or without covers and reflectors. Reflectors increase the performance of the solar ponds by about 25%. Finally, this model has been employed for the prediction of temperature variations of an experimental salt gradient solar pond. Numerical results are in good agreement with the experiments.

08/02816 Optimal arrangement of structural and functional parts in a flat plate integrated collector storage solar water heater (ICSSWH)

Gertzos, K. P. and Caouris, Y. G. *Experimental Thermal and Fluid Science*, 2008, 32, (5), 1105–1117.

Parameters that affect the efficiency of a flat plate integrated collector storage solar water heater (ICSSWH) are examined experimentally and numerically. This specific ICSSWH contains water that is not refreshed. The service water is heated indirectly through an immersed heat exchanger in contact with the front and back major surfaces. A forced convection mechanism consisting of a pump that brings the storage water into motion by recirculation is used for heat transfer intensification. The two major (front and back) flat plate surfaces need to be well interconnected so that they are not deformed by the weight of the contained water and the exerted high-pressure. Two main factors that influence the performance are optimized: the position and size of the recirculation ports and the arrangement and size of the interconnecting fins. Both factors are explored to maximize the velocity flow field of the recirculated storage water. Consequently, the heat transfer rate between the two water circuits is maintained at high levels. Various three-dimensional computational fluid dynamics models are developed using the FLUENT package. An experimental model, made by Plexiglas, is used for the visualization of the flow field. Flow velocities are measured using a laser doppler velocimetry system. The optimal arrangement increases the mean storage water velocity by 65% and raises the outlet temperatures up to 8 °C.

08/02817 Prediction and validation of cloudless shortwave solar spectra incident on horizontal, tilted, or tracking surfaces

Gueymard, C. A. *Solar Energy*, 2008, 82, (3), 260–271.

The SMARTS spectral model can advantageously be used to predict clear-sky irradiance spectra on surfaces of any tilt and orientation, e.g. for the simulation of spectrally selective technologies like photovoltaic devices or coated fenestration systems. To evaluate the intrinsic accuracy of the model, its current version undergoes here a three-step validation exercise, involving reference radiative transfer codes, and two series of sophisticated spectral and ancillary measurements performed at different locations. Provided that the most important inputs are known with sufficient accuracy, it is concluded that the model performance is very high, with typical differences of 1–2% when compared to reference models, and uncertainties largely within the overall experimental error ($\approx$5%) when compared to spectroradiometric measurements. The effect of imprecise spectral reflectance data of the foreground on the diffuse irradiance incident on shaded vertical surfaces is discussed.

08/02818 Satellite approach based on cloud cover classification: estimation of hourly global solar radiation from Meteosat images

Mefti, A. *et al. Energy Conversion and Management*, 2008, 49, (4), 652–659.

Hourly global solar irradiation data useful for the design of solar energy conversion systems is generated using a new satellite based model called SICIC (solar irradiation from cloud image classification). It is a model built by processing high resolution visible Meteosat images and ground measurements of solar radiation flux collected in various locations of France during the 1994/95 period. Taking into account the hourly variability of solar radiation flux, SICIC begins by sorting the sun elevation angles into representative classes. For each location and each class, the clearness index is then computed, and the grey levels of the pixels of the visible Meteosat images are converted into cloud cover indexes. Next, two adjustable thresholds are used to split the set of cloud cover indices into three subsets representing clear, partly covered and overcast skies, respectively. Finally, three regression equations linking the clearness and cloud cover indices are obtained for the three sky categories. In these equations, the SICIC parameters (the regression coefficients and both thresholds) vary against the solar elevation angle. SICIC then yields a good estimate of the hourly global solar irradiation flux for every site displayed in the Meteosat images. This model is compared to GISTEL, which is another model governed by the same hypotheses as SICIC but differing by the invariability of its parameters in time. SICIC is found to be more accurate than GISTEL. In particular, the hourly solar data are estimated with an error varying from 32% to 12% for SICIC and 44% to 14% for GISTEL when the sun altitude increases from 15° to 75°. At the daily scale, SICIC is also more efficient than GISTEL. It has been satisfactorily applied to other sites of France and Algeria. The tests made on Wefax and B2 Meteosat images show that this model can be easily extended to other satellite images.

08/02819 Studies of the pulse charge of lead-acid batteries for PV applications Part I. Factors influencing the mechanism of the pulse charge of the positive plate

Kirchev, A. *et al. Journal of Power Sources*, 2008, 177, (1), 217–225.

The mechanism of the positive plate charge in pulse regime was studied in model lead-acid cells with one positive and two negative plates (8 Ah each) and Ag/Ag_2SO_4 reference electrodes. The results showed that the evolution of the electrode potential is much slower on the positive plate than on the negative plate. Regardless of this fact, the calculated capacitive current of charge and self-discharge of the electrochemical double layer (EDL) during the 'ON' and 'OFF' half-periods of the pulse current square waves is comparable with the charge current amplitude. The result is due to the high values of the EDL on the surface of the lead dioxide active material. The influence of different factors like state of charge, state of health, pulse frequency, current amplitude and open circuit stay before the polarization was discussed. The previously determined optimal frequency of 1 Hz was associated with a maximum in the average double layer current on frequency dependence. The average double layer current is also maximal at SOC between 75 and 100%. The exchange of the constant current polarization with pulse polarization does not change substantially the mechanism and the overvoltage of the oxygen evolution reaction on the positive plate. The mechanism of the self-discharge of the EDL was also estimated analysing long-time PPP transients (up to 2 h). It was found that when the PPP is lower than 1.2 V the preferred mechanism of EDL self-discharge is by coupling with the lead sulphate oxidation reaction. At higher values of PPP the EDL self-discharge happens via oxygen evolution. The high faradic efficiency of the pulse charge is due to the chemical oxidation of the Pb(II) ions by the O atoms and OH radicals formed at the oxygen evolution both during the 'ON' and 'OFF' periods.

08/02820 Studies on a heat-recirculating microemitter for a micro thermophotovoltaic system

Lee, K. H. and Kwon, O. C. *Combustion and Flame*, 2008, 153, (1–2), 161–172.

A new microemitter (microcombustor) configuration for a micro thermophotovoltaic system in which thermal energy is directly converted into electrical energy through thermal radiation was investigated experimentally and computationally. The microemitter as a thermal heat source was designed for a 1–10 W power-generating micro thermophotovoltaic system. To satisfy the primary requirements for designing the microemitter (stable burning in the small confinement, maximum heat transfer through the emitting walls, but uniform distribution of temperature along the walls), the present microemitter is cylindrical with an annular-type shield to apply for the heat-recirculation concept. Results show that the heat recirculation substantially improves the performance of the microemitter: the observed and predicted thermal radiation from the microemitter walls indicated that heat generated in the microemitter is uniformly emitted. Thus, the present microemitter configuration can be applied to the practical micro thermophotovoltaic systems without any moving parts (hence frictional losses and clearance problems are avoided). Ratios of the inner radius of the shield to the gap between the shield and microemitter walls and the microemitter wall thickness substantially affect thermal characteristics.

08/02821 Study on thermal performance of semi-transparent building-integrated photovoltaic glazings

Fung, T. Y. Y. and Yang, H. *Energy and Buildings*, 2008, 40, (3), 341–350.

This paper presents a one-dimensional transient heat transfer model, the semi-transparent photovoltaic module heat gain (SPVHG) model, for evaluating the heat gain of semi-transparent photovoltaic modules for building-integrated applications. The energy that is transmitted, absorbed and reflected in each element of the building-integrated photovoltaic modules such as solar cells and glass layers were considered in detail in the SPVHG model. Solar radiation model for inclined surface has been incorporated into the SPVHG model. The model is applicable to photovoltaic (PV) modules that have different orientations and inclinations. The annual total heat gain was evaluated by using the SPVHG model. The impacts of different parameters of the PV module were investigated. It was found that solar heat gain is the major component of the total heat gain. The area of solar cell in the PV module has significant effect on the total heat gain. However, the solar cell energy efficiency and the PV module's thickness have only a little influence on the total heat gain. The model was also validated by laboratory tests by using a calorimeter box apparatus and an adjustable solar simulator. The test results showed that the simulation model predicts the actual situation well.

08/02822 Technical feasibility assessment of a solar chimney for food drying

Ferreira, A. G. *et al. Solar Energy*, 2008, 82, (3), 198–205.

Solar dryers use free and renewable energy sources, reduce drying losses (as compared to sun drying) and show lower operational costs than the artificial drying, thus presenting an interesting alternative to conventional dryers. This work proposes to study the feasibility of a solar chimney to dry agricultural products. To assess the technical feasibility of this drying device, a prototype solar chimney, in which the air velocity, temperature and humidity parameters were monitored as a function of the solar incident radiation, was built. Drying tests of food, based on theoretical and experimental studies, assure the technical feasibility of solar chimneys used as solar dryers for agricultural products. The constructed chimney generates a hot airflow with a yearly average rise in temperature (compared to the ambient air temperature) of $13 \pm 1\,^{\circ}\mathrm{C}$. In the prototype, the yearly average mass flow was found to be 1.40 ± 0.08 kg/s, which allowed a drying capacity of approximately 440 kg.

08/02823 The assessment of four different correction models applied to the diffuse radiation measured with a shadow ring using global and normal beam radiation measurements for Beer Sheva, Israel

Kudish, A. I. and Evseev, E. G. *Solar Energy*, 2008, 82, (2), 144–156.
The measurement of the diffuse radiation incident on a horizontal surface, a priori a straightforward task, is fraught with difficulties. It is possible to measure the diffuse radiation by three different techniques: two of which measure it directly and the third indirectly. The most accurate is the indirect one, which is based upon the concurrent measurements of the horizontal global and the normal incidence beam radiation. The disadvantage of this being the relatively expensive tracking system required for measuring the latter. The diffuse radiation can be measured directly with a pyranometer outfitted with either an occulting disk or shadow ring, which prevent the beam radiation from impinging on the pyranometer sensor. The occulting disk can provide accurate measurements of the diffuse radiation but it requires a relatively expensive sun tracking system in the east–west axis. The shadow ring is a stationary device with regard to the east–west axis and blocks the beam radiation component by creating a permanent shadow on the pyranometer sensor. The major disadvantage of the shadow ring is that it also blocks that portion of the diffuse radiation obscured by the shadow ring. This introduces a measurement error that must be corrected to account for that portion of the sky obscured by the shadow band. In addition to this geometric correction factor there is a need to correct for anisotropic sky conditions. Four correction models have been applied to the data for Beer Sheva, Israel and the results have been evaluated both graphically and statistically. An attempt has been made to score the relative performance of the models under different sky conditions.

08/02824 The strategic siting and the roofing area requirements of building-integrated photovoltaic solar energy generators in urban areas in Brazil

da Silva Jardim, C. *et al. Energy and Buildings*, 2008, 40, (3), 365–370.
Building-integrated photovoltaic generators are typically small and distributed solar power plants that occupy virtually no space because they are part of the building envelope, and they generate power at point of use. A more widespread use of grid-connected photovoltaics (PV) is hindered by a number of reasons including the declining, but still high costs of the photogenerated kilowatt hour, and the lack of knowledge about the benefits of distributed generation with PV in the urban environment. When strategically sited, PV generators integrated to building façades and rooftops in urban areas at limited penetration levels can benefit local feeders with these distributed 'negative loads'. A number of studies have been published, with learning curves demonstrating the cost-reduction potential of large-scale PV production, and in some markets the cost of PV electricity is approaching residential tariffs, the so-called grid parity. Due to the intermittent nature of the solar radiation resource, PV is considered non-despatchable power, but under some conditions, in sunny urban areas with electricity load curves dominated by air-conditioning loads, there is a high correlation between PV generation and feeder loads. In these situations, a considerable fraction of a given PV generator can be considered despatchable power. In this work, the potential of building-integrated, grid-connected PV generation is assessed in the state capital Florianópolis, in South Brazil. The deployment of six different commercially available PV technologies is compared with total roof area availability, solar generation profiles, and local feeder load curves for a selected number of urban areas in the city. The results demonstrate the advantages of strategically siting PV generators in the urban environment.

Wind energy

08/02825 A fuzzy controller for maximum energy extraction from variable speed wind power generation systems

Calderaro, V. *et al. Electric Power Systems Research*, 2008, 78, (6), 1109–1118.
The wind power production spreading, also aided by the transition from constant to variable speed operation, involves the development of efficient control systems to improve the effectiveness of wind systems. This paper presents a data-driven design methodology able to generate a Takagi–Sugeno–Kang (TSK) fuzzy model for maximum energy extraction from variable speed wind turbines. In order to obtain the TSK model, fuzzy clustering methods for partitioning the input–output space, combined with genetic algorithms, and recursive least-squares optimization methods for model parameter adaptation are used. The implemented TSK fuzzy model, as confirmed by some simulation results on a doubly fed induction generator connected to a power system, exhibits high speed of computation, low memory occupancy, fault tolerance and learning capability.

08/02826 Considerations on the backup of wind power: operational backup

Luickx, P. J. *et al. Applied Energy*, 2008, 85, (9), 787–799.
The introduction of wind power into an electricity-generation system on a large scale brings about challenges for the evolution and operation of this system: backup for wind power becomes a necessity. This paper defines various elements that come into play when considering backup for electricity generation from wind power. The backup is split up in capacity backup and operational backup. The focus is set on the short-term, operational aspects of the backup provision. The effects of several short-term operation related parameters are defined and analysed. Most relevant parameters for the operation and needs for wind power backup are the load profiles, the wind power output profiles and the total amount of installed wind power. These are analysed by means of a mixed integer linear programming model through two different methods for operational backup provision, comparing the incremental cost, generated by both methods. The first method applies wind power backup through a 100% provision of additional spinning reserves. The second method does not foresee any spinning reserve and relies on the balancing by the transmission system operator (TSO). Both methods result in different additional charges that are being affected by the said parameters. Both the wind profile and the total amount of installed wind power are positively related to the relative cost increase. The load profile is negatively correlated to this increase. The relationship between these parameters and the development of the incremental cost provides an understanding that allows finding better equilibria in the operational backup of wind power.

08/02827 Short term hydroelectric power system scheduling with wind turbine generators using the multi-pass iteration particle swarm optimization approach

Lee, T.-Y. *et al.*, *Energy Conversion and Management*, 2008, 49, (4), 751–760.
This paper uses multi-pass iteration particle swarm optimization (MIPSO) to solve short-term hydroelectric generation scheduling of a power system with wind turbine generators. MIPSO is a new algorithm for solving non-linear optimal scheduling problems. A new index called iteration best is incorporated into particle swarm optimization to improve solution quality. The concept of multi-pass dynamic programming is applied to modify PSO further and improve computation efficiency. The feasible operational regions of the hydro units and pumped storage plants over the whole scheduling time range must be determined before applying MIPSO to the problem. Wind turbine power generation then shaves the power system load curves. Next, MIPSO calculates hydroelectric generation scheduling. It begins with a coarse time stage and searching space and refines the time interval between two time stages and the search spacing pass by pass (iteration). With the cooperation of agents called particles, the near optimal solution of the scheduling problem can be effectively reached. The effects of wind speed uncertainty were also considered in this paper. The feasibility of the new algorithm is demonstrated by a numerical example, and MIPSO solution quality and computation efficiency are compared to those of other algorithms.

08/02828 Simulations of wind power integration with complementary power system planning tools

Sørensen, P. *et al. Electric Power Systems Research*, 2008, 78, (6), 1069–1079.
This paper describes a procedure for simulations of wind power integration in a deregulated power system with two complementary planning tools. The first planning tool is a joint market model (JMM) taking into account the day-ahead market and the regulating power market using 1 h average time steps. The second tool is the stepwise power flow (SPF) model simulating the frequency deviations and power balancing within the hour, e.g. based on 5 min average time steps. Input data is shared by the two tools, and the simulation results from JMM are used in the SPF simulations to ensure consistent results. JMM simulations are performed using two different scenarios for the development in the Nordic power system. The first scenario is the most likely development for 2010, and the second is a high-wind scenario

assuming 10% of the electricity consumption in the Nordic countries supplied by wind power. Subsequently, a worst case 1 h period is selected from the JMM simulations, converted to the more detailed grid representation in SPF, and finally simulated and analysed with SPF.

08/02829 Stakeholders' perspectives on barriers to remote wind–diesel power plants in Canada

Weis, T. M. *et al. Energy Policy*, 2008, 36, (5), 1611–1621.

Canada has been experimenting with wind–diesel hybrid systems for its remote communities for over 25 years with limited success. This paper discusses the results of a year-long survey that was distributed to stakeholders in wind–diesel systems in remote Canadian communities. These stakeholders include utilities, wind energy technology manufacturers, project developers, researchers, and governments. The analysis shows that there is a strong agreement that capital and operating costs are the most significant barriers to the implementation of wind–diesel systems and that direct project financial incentives, notably production and capital cost incentives designed to reduce these costs are perceived as the most effective way to encourage development. There is a notable disagreement between utilities and governments on one hand, who are split as to the current technical viability of wind–diesel systems, and manufacturers, developers, and researchers on the other, who overwhelmingly believe that wind–diesel systems are mature enough for remote applications.

08/02830 The economic benefit of short-term forecasting for wind energy in the UK electricity market

Barthelmie, R. J. *et al. Energy Policy*, 2008, 36, (5), 1687–1696.

In the UK market, the total price of renewable electricity is made up of the Renewables Obligation Certificate and the price achieved for the electricity. Accurate forecasting improves the price if electricity is traded via the power exchange. In order to understand the size of wind farm for which short-term forecasting becomes economically viable, a model for wind energy was developed. Simulations were carried out for 2003 electricity prices for different forecast accuracies and strategies. The results indicate that it is possible to increase the price obtained by around £5/MWh which is about 14% of the electricity price in 2003 and about 6% of the total price. It is shown that the economic benefit of using short-term forecasting is also dependent on the accuracy and cost of purchasing the forecast. As the amount of wind energy requiring integration into the grid increases, short-term forecasting becomes more important to both wind farm owners and the transmission/distribution operators.

08/02831 Use of MinMaxEnt distributions defined on basis of MaxEnt method in wind power study

Shamilov, A. *et al. Energy Conversion and Management*, 2008, 49, (4), 660–677.

Knowledge of the wind speed distribution is an important information needed in evaluation of wind power potential. Several statistical distributions have been used to study wind data. The Weibull distribution is the most popular due to its ability to fit most accurately the variety of wind speed data measured at different geographical locations throughout the world. Recently, maximum entropy (MaxEnt) distributions based on the maximum entropy method have been widely used to determine wind speed distribution. Li and Li used the MaxEnt distribution for the first time in the wind energy field and proposed a theoretical approach to determine the distribution of wind speed data analytically. Ramirez and Carta discussed the use of wind probability distributions derived from the maximum entropy principle in the analysis of wind energy. In this study, MinMaxEnt distributions defined on the basis of the MaxEnt method are introduced and applied to find wind distribution and wind power density. A comparison of the MinMaxEnt and Weibull distributions on wind speed data taken from different sources and measured in various regions is conducted. The wind power densities of the considered regions obtained from the Weibull and MinMaxEnt distributions are also compared. The results indicate that the MinMaxEnt distributions obtained show better results than the known Weibull distribution for wind speed distributions and wind power density. Therefore, MinMaxEnt distributions can be used to estimate wind distributions and wind power potential.

Others, including economics

08/02832 Assessment of straw biomass feedstock resources in the Pacific Northwest

Banowetz, G. M. *et al. Biomass and Bioenergy*, 2008, 32, (7), 629–634.

Straw that is produced as a coproduct of cereal grain and grass seed production on 24,000 km^2 in the Pacific Northwest states of Idaho (ID), Oregon (OR) and Washington (WA) has potential as a bioenergy feedstock. Previous attempts to develop approaches to convert straw to energy based on transporting straw to a conversion facility were uneconomical. Rising energy prices and the availability of new technologies have renewed interest in converting these lignocellulosic residues to energy products, especially liquid fuels, but information on the distribution of these resources is lacking. Development of an economic approach to convert this straw to energy will require an assessment of the regional distribution of available straw to identify an appropriate scale of conversion technology that optimally reduces straw collection and transportation costs. County-scale US Department of Agriculture (USDA) National Agricultural Statistical Service (NASS) data are utilized to quantify total grass seed and cereal straw production in each county of ID, OR and WA, subtracted the county-specific quantity of field residue for each crop, and developed an estimate of available straw, that remaining after sufficient straw is returned to the soil for conservation. At current straw yields, over 6.5 Mt of straw in excess of that required for conservation purposes are available in the region. This straw is distributed across the landscape at an average density of 2.4 Mg ha^{-1} and in many locations will require small- or local-scale technology to enable economical conversion of the feedstock to energy.

08/02833 Biomass market and trade in Norway: status and future prospects

Trømborg, E. *et al. Biomass and Bioenergy*, 2008, 32, (8), 660–671.

This paper gives an overview of bioenergy use, prices, markets and markets prospects in Norway. The current energy production based on biomass in Norway is about 50 pJ or 10% of the stationary energy consumption. About one-half is produced and used in forest industries. The main share of bioenergy used by households consists of firewood in stoves. The use of refined, solid biofuels in heat production is hampered by low coverage of water-borne heating systems and historically low end-user prices of electricity. Harvest levels in Norwegian forests are much below annual growth, implying that forest biomass resources steadily accumulate. Decreasing wood prices combined with rising prices of oil and electricity in recent year have improved competitiveness of solid biofuels in the heat market. Projections of future bioenergy use in Norway using a partial equilibrium forest sector model suggest that bioenergy use will increase in some market segments with the current price levels of electricity and oil. However, quite minor improvements of bioenergy competitiveness or increased energy prices may release substantially higher bioenergy use. A net increase in bioenergy use of 5 TWh (18 PJ) by 2010 is realistic, but requires public awareness of the opportunities in bioenergy technologies, as well as significant economic incentives. Wood stoves and the replacement of oil-boilers in central heating systems show highest competitiveness, whereas district heating systems require higher energy prices or more subsidies to be competitive. Biomass for combined heat and power projects or domestically produced liquid biofuels seems to have limited competitiveness in the short term. On the raw material side, wood residues, and roundwood from pine and non-coniferous species represent the main potential, whereas spruce continues to be consumed by the forest industries. According to the model projections, imported biomass will take a significant share of the possible increase of wood consumption in Norway.

08/02834 Conventional and in situ transesterification of sunflower seed oil for the production of biodiesel

Georgogianni, K. G. *et al. Fuel Processing Technology*, 2008, 89, (5), 503–509.

In the present work the alkaline transesterification of sunflower seed oil with methanol and ethanol, for the production of biodiesel fuel was studied. Both conventional and *in situ* transesterification were investigated using low frequency ultrasonication (24 kHz) and mechanical stirring (600 rpm). Use of ultrasonication in conventional transesterification with methanol gave high yields of methyl esters (95%) after a short reaction time (20 min) similar to those using mechanical stirring. Use of ultrasonication in conventional transesterification with ethanol gave similar yields to those using mechanical stirring but significantly lower than respective yields using methanol. In the *in situ* transesterification the use of ultrasonication and mechanical stirring led to similar high yields (95%) of methyl esters after approximately 20 min of reaction time. In the presence of ethanol use of ultrasonication led to high ester yields (98%) in only 40 min of reaction time while use of mechanical stirring gave lower yields (88%) even after 4 h of reaction time. *In situ* transesterification gave similar ester yields to those obtained by conventional transesterification being an alternative, efficient and economical process. In all cases a concentration of 2.0% sodium hydroxide gave higher ester yields. The reaction rate constants were calculated, using first-order reaction kinetics, to be equal to $3.1 \times 10^{-3}\,s^{-1}$ for conventional transesterification using methanol and 2.0% sodium hydroxide, and $9.5 \times 10^{-4}\,s^{-1}$ using ethanol.

08/02835 Design and techno-economical optimization for hybrid PV/wind system under various meteorological conditions

Diaf, S. *et al. Applied Energy*, 2008, 85, (10), 968–987.

The optimal design of the renewable energy system can significantly improve the economical and technical performance of power supply. In this paper, the technical-economic optimization study of a stand-alone hybrid PV/wind system in Corsica Island is presented. Therefore, the primary objective of this study is to estimate the appropriate dimensions of a stand-alone HPWS that guarantee the energy autonomy of a typical remote consumer with the lowest levelized cost of energy (LCE). A secondary aim is to compare the performance and the optimal sizing of two system configurations. Finally, to study the impact of the renewable energy potential quality on the system size, the optimum dimensions of system are defined for five sites in Corsica Island. In this context, a complete sizing model is developed, able to predict the optimum system configuration on the basis of LCE. Accordingly, an integrated energy balance analysis is carried out for the whole time period investigated. The simulation results indicate that the hybrid system is the best option for all the sites considered in this study, yielding lower LCE. Thus, it provides higher system performance than PV or wind systems alone. The choice of the system configuration type affects the state of charge variation profile, especially at low wind potential sites, while the system size and the LCE are significantly influenced. It is shown that the LCE depends largely on the renewable energy potential quality. At high wind potential site, more than 40% of the total production energy is provided by the wind generator, while at low wind potential sites, less than 20% of total production energy is generated by the wind generator.

08/02836 Effect of stove asymmetric radiation field on thermal comfort using a multisegmented bioheat model

Ghali, K. *et al. Building and Environment*, 2008, 43, (7), 1241–1249.

The multinode multisegment bioheat model of Salloum *et al.* is integrated with a space heat model to study human thermal response when subjected to radiant asymmetry in stove-heated domestic spaces in Lebanon. For any given person position, the overall comfort level is based on Frank *et al.* model correlations. The assessment of local comfort level is based on the maximum deviation of the clothed segments skin temperature from the mean skin temperature and its relation to the radiant temperature asymmetry. Experiments were run on human subjects at steady-state conditions to measure the variation of the skin temperature at different locations of the human body segments while standing in an asymmetric thermal radiation field generated by a stove-heating unit. The experiments were conducted to validate the applicability of the bioheat model in predicting skin temperature in asymmetric conditions. The measured skin temperature of various body segments and the radiative asymmetry agreed within ±5% of values predicted by the bioheat model. The space heat model and the bioheat model are applied to a case study to predict both overall thermal comfort and local thermal discomfort in a typical radiant heat space at different standing positions of the person. Strong thermal discomfort exists within the vicinity of the stove high-temperature surface. The local discomfort is considered at values of maximum $SD > 1.1\,^{\circ}C$ derived from consideration of Fanger *et al.* data of comfort limits and skin temperature measurements for asymmetric thermal radiation.

08/02837 Fuel ethanol from cane molasses in Thailand: environmental and cost performance

Nguyen, T. L. T. and Gheewala, S. H. *Energy Policy*, 2008, 36, (5), 1589–1599.

In the context of the world's energy crisis and environmental concerns, crop-based ethanol has emerged as an energy alternative, the use of which can help reduce oil imports as well as emissions of CO_2 and other air pollutants. However, a clear disadvantage of ethanol is its high cost over gasoline under the current pricing scheme that does not include externalities. The intent of this study is to perform a life cycle analysis comparing environmental and cost performance of molasses-based E10 with those of CG. The results show that although E10 provides reduction in fossil energy use, petroleum use, CO_2 and NO_x emissions, its total social costs are higher than those of gasoline due to higher direct production costs and external costs for other air emissions, e.g. CH_4, N_2O, CO, SO_2, VOC and PM_{10}. An analysis of projection scenarios shows that technological innovations towards cleaner production help maximize ethanol's benefits whilst minimizing its limitations.

08/02838 Integration of thermoelectrics and photovoltaics as auxiliary power sources in mobile computing applications

Muhtaroglu, A. *et al. Journal of Power Sources*, 2008, 177, (1), 239–246.

The inclusion of renewable technologies as auxiliary power sources in mobile computing platforms can lead to improved performance such as the extension of battery life. This paper presents sustainable power management characteristics and performance enhancement opportunities in mobile computing systems resulting from the integration of thermoelectric generators and photovoltaic units. Thermoelectric generators are employed for scavenging waste heat from processors or other significant components in the computer's chipset while the integration of photovoltaic units is demonstrated for generating power from environmental illumination. A scalable and flexible power architecture is also verified to effectively integrate these renewable energy sources. This paper confirms that battery life extension can be achieved through the appropriate integration of renewable sources such as thermoelectric and photovoltaic devices.

08/02839 Introduction to integration of renewable energy in demand controlled hybrid ventilation systems for residential buildings

Antvorskov, S. *Building and Environment*, 2008, 43, (8), 1350–1353.

In the scope of the EU supported project residential buildings hybrid ventilation, the possible integration of renewable energy solutions (RES) into hybrid ventilation systems has been analysed. The focus has been on solar and wind applications to substitute the use of fossil fuel. The feasibility of the investigated options depends on the ventilation concept the RES is integrated into, the location of the building geographically, placement of the RES in the building and on the urban environment. This paper describes the different renewable technologies, options and constraints in connection with integration into hybrid ventilation systems.

08/02840 Methodological aspects on international biofuels trade: international streams and trade of solid and liquid biofuels in Finland

Heinimö, J. *Biomass and Bioenergy*, 2008, 32, (8), 702–716.

The use of biomass for fuel is increasing in industrialized countries. Rapidly developing biomass markets for energy purposes along with weak information on biofuels trade that statistics offer have been incentives for several recently published studies investigating the status of biofuels trade. The comparison of the studies is often challenging due particularly to the various approaches to the indirect trade of biofuels and the diverse data sources utilized. The purpose of this study was to provide an overview of the Finnish situation with respect to the status of the streams of international biofuels trade. Parallel to this, the study aimed to identify methodological and statistical challenges in observing international biofuels trade. The study analysed available statistical information and introduced a procedure to obtain a clear overview on import and export streams of biofuels. In Finland, the total direct import and export of biofuels, being mainly composed of wood pellets and tall oil, is tiny in comparison with the total consumption of biofuels. Instead, the indirect trade has remarkable importance. Large import volumes of industrial raw wood make Finland a net importer of biofuels. In 2004, approximately 22% (64 PJ) of wood-based energy in Finland originated from imported wood. The study showed that the indirect trade of biofuels may be a significant sector of global biofuels trade. In the case of Finland, a comprehensive compilation of statistics on energy and forestry enabled the determination of the trade status satisfactory. However, national and international statistics should be further developed to take better into consideration international trade and to support continuously developing biofuels markets.

08/02841 More competition: threat or chance for financing renewable electricity?

Szabó, S. and Jäger-Waldau, A. *Energy Policy*, 2008, 36, (4), 1436–1447.

The paper examines how increased competition in electricity markets may reshape the future electricity generation portfolio and its potential impact on the renewable energy (RE) within the energy mix. The present analysis, which is based on modelling investor behaviour with a time horizon up to 2030, considers the economic aspects and conditions for this development with a particular focus on the photovoltaics. These aspects include pure financial/investment factors, such as the expected returns in the sector, subsidization of certain RE resources and other policies focusing on the energy sector (liberalization, environmental policies and security of supply considerations). The results suggest that policies aiming at the expansion of renewable energy technologies and strengthening the competition in the electricity markets have mutually reinforcing effects. More competition can reduce the financial burden of the existing renewable support schemes and consequently help to achieve the already established RE targets.

08/02842 Numerical modelling in wave energy conversion systems

El Marjani, A. *et al. Energy*, 2008, 33, (8), 1246–1253.

This paper deals with a numerical modelling devoted to predict the flow characteristics in the components of an oscillating water column system used for the wave energy capture. In the present paper, the flow behaviour is modelled by using the FLUENT code. Two numerical flow models have been elaborated and tested independently in the geometries of an air chamber and a turbine, which is chosen of a radial impulse type. The flow is assumed to be three-dimensional, viscous, turbulent and unsteady. The FLUENT code is used with a solver of the coupled conservation equations of mass, momentum and energy, with an implicit time scheme and with the adoption of the dynamic mesh and the sliding mesh techniques in areas of moving surfaces. Turbulence is modelled with the k–ε model. The obtained results indicate that the developed models are well suitable to analyse the air flows both in the air chamber and in the turbine. The performances associated with the energy transfer processes have been well predicted. For the turbine, the numerical results of pressure and torque were compared to the experimental ones. Good agreements between these results have been observed.

08/02843 Optimal sizing method for stand-alone hybrid solar–wind system with LPSP technology by using genetic algorithm

Yang, H. *et al. Solar Energy*, 2008, 82, (4), 354–367.

System power reliability under varying weather conditions and the corresponding system cost are the two main concerns for designing hybrid solar–wind power generation systems. This paper recommends an optimal sizing method to optimize the configurations of a hybrid solar–wind system employing battery banks. Based on a genetic algorithm (GA), which has the ability to attain the global optimum with relative computational simplicity, one optimal sizing method was developed to calculate the optimum system configuration that can achieve the customers required loss of power supply probability (LPSP) with a minimum annualized cost of system (ACS). The decision variables included in the optimization process are the PV module number, wind turbine number, battery number, PV module slope angle and wind turbine installation height. The proposed method has been applied to the analysis of a hybrid system which supplies power for a telecommunication relay station, and good optimization performance has been found. Furthermore, the relationships between system power reliability and system configurations were also given.

08/02844 Promoting biofuels: implications for developing countries

Peters, J. and Thielmann, S. *Energy Policy*, 2008, 36, (4), 1538–1544.

Interest in biofuels is growing worldwide as concerns about the security of energy supply and climate change are moving into the focus of policy makers. With the exception of bioethanol from Brazil, however, production costs of biofuels are typically much higher than those of fossil fuels. As a result, promotion measures such as tax exemptions or blending quotas are indispensable for ascertaining substantial biofuel demand. With particular focus on developing countries, this paper discusses the economic justification of biofuel promotion instruments and investigates their implications. Based on data from India and Tanzania, it is found that substantial biofuel usage induces significant financial costs. Furthermore, acreage availability is a binding natural limitation that could also lead to conflicts with food production. Yet, if carefully implemented under the appropriate conditions, biofuel programs might present opportunities for certain developing countries.

08/02845 Proposing a new advanced control technique for micro hydro power plants

Hanmandlu, M. and Goyal, H. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 272–282.

Micro hydropower plants are emerging as a major renewable energy resource today as they do not encounter the problems of population displacement and environmental problems associated with the large hydro power plants. However, they require control systems to limit the huge variation in input flows expected in rivulets over which these are established to produce a constant power supply. This paper proposes an electric servomotor as a governor for a micro hydro power plant especially those plants that are operated in isolated mode. An advanced controller is developed combining four control schemes for the control of the governor following the concept that the control action can be split up into linear and non-linear parts. The linear part of this controller contains an adaptive fast transversal filter (FTF) algorithm and normalized LMS (nLMS) algorithm. The non-linear part of the controller incorporates Fuzzy PI and a neural network. The concept behind splitting the control action is reasoned out and the conditions for stability of the controller are proved. The new controller has a superior performance compared to other control schemes.

08/02846 Renewable energy utilization evaluation method in green buildings

Xia, C. *et al. Renewable Energy*, 2008, 33, (5), 883–886.

Utilizing renewable energy (RE) is an important part of the design and development of green buildings. However, it is unreasonable to assess renewable energy utilization (REU) only with the net ratio of end-use energy provided by the renewable energy system to a building's total energy consumption, but ignoring the system efficiency of REU with the necessary extra conventional energy consumption, such as electricity. In this paper, the energy quality coefficient is introduced to describe the quality of energy, while the energy conversion coefficient is applied to evaluate energy system efficiency. The indexes and their expressions were developed based on exergy analysis. Based on these two indexes, an effective substitution ratio (ESR) was developed for the evaluation of REU. Furthermore, the ESR of utilizing RE to substitute for single type and multiple types of conventional energy is discussed. Finally, case studies were conducted and some conclusions were drawn from the results for application of RE in buildings.

08/02847 Size optimization of a PV/wind hybrid energy conversion system with battery storage using response surface methodology

Ekren, O. and Ekren, B. Y. *Applied Energy*, 2008, 85, (11), 1086–1101.

This paper aims to show the use of the response surface methodology (RSM) in size optimization of an autonomous PV/wind integrated hybrid energy system with battery storage. RSM is a collection of statistical and mathematical methods which relies on optimization of response surface with design parameters. In this study, the response surface, output performance measure, is the hybrid system cost, and the design parameters are the PV size, wind turbine rotor swept area and the battery capacity. The case study is realized in ARENA 10.0, a commercial simulation software, for satisfaction of electricity consumption of the global system for mobile communications (GSM) base station at Izmir Institute of Technology Campus Area, Urla, Turkey. As a result, the optimum PV area, wind turbine rotor swept area, and battery capacity are obtained to be 3.95 m^2, 29.4 m^2, 31.92 kWh, respectively. These results led to $37,033.90 hybrid energy system cost, including auxiliary energy cost. The optimum result obtained by RSM is confirmed using loss of load probability and autonomy analysis.

08/02848 Systematic procedure for efficient design of electric water pumping systems fed by PV or/and WECS: application using measured meteorological data for the city of Xanthi/Thrace, Greece

Skretas, S. B. and Papadopoulos, D. P. *Energy Conversion and Management*, 2008, 49, (4), 596–607.

The scope of this paper is to propose a systematic and efficient design procedure for application to either a photovoltaic powered electric water pumping system (PPEWPS) or a wind powered electric water pumping system (WPEWPS). The main aims of this procedure are: (1) to have either the PV type generator or the fixed pitch small size wind turbine with direct driven permanent magnet synchronous generator operate always at its maximum power point and (2) to have the separately excited DC motor/pump system (i.e. the load of the system) operate, also and at all times, with its nominal speed n_{nom}. A problem with the PPEWPS and WPEWPS is that, while the proposed control strategy using artificial neural networks leads to satisfactory operation with minimal sensors, the armature voltage $U_{\mathrm{alpha;}}$ of the DC motor remains much smaller than its nominal value (especially for very low solar radiations or wind velocities), which may result in non-acceptable motor operation. A practical solution to this problem may be the combined use of the two mentioned systems to form a hybrid electric water pumping system (HEWPS). The PPEWPS, WPEWPS and HEWPS are designed and investigated thoroughly using the proposed systematic procedure and Matlab software for the purpose of an installation under consideration for the city of Xanthi (Thrace Region), Greece.

08/02849 Techno-economical study of hybrid power system for a remote village in Algeria

Himri, Y. *et al. Energy*, 2008, 33, (7), 1128–1136.

The share of renewable energy sources in Algeria primary energy supply is relatively low compared with European countries, though the trend of development is positive. One of the main strategic priorities of New Energy Algeria (NEAL), which is Algeria's renewable energy agency (government, Sonelgaz and Sonatrach), is striving to achieve a share of 10–12% renewable energy sources in primary energy supply by 2010. This article presents techno-economic assessment for off-grid hybrid generation systems of a site in south western Algeria. The HOMER model is used to evaluate the energy production, life-cycle costs and greenhouse gas emissions reduction for this study. In the present scenario, for wind speed less than 5.0 m/s the existing diesel power plant is the only feasible solution over the range of fuel prices used in the simulation. The wind diesel hybrid system becomes feasible at a wind speed of 5.48 m/s or more and a fuel price of 0.162$/L or more. If the carbon tax is taken into consideration and subsidy is abolished, then it is expected that the hybrid system will become feasible. The maximum annual capacity shortage did not have any effect on the cost of energy, which may be accounted for by larger sizes of wind machines and diesel generators.

08/02850 The economics of harvesting and transporting corn stover for conversion to fuel ethanol: a case study for Minnesota

Petrolia, D. R. *Biomass and Bioenergy*, 2008, 32, (7), 603–612.

Corn-stover feedstock costs were estimated for a proposed biomass-to-ethanol conversion facility in southern Minnesota, USA, accounting for county-specific yields and transportation distances, erosion constraints, machinery specifications, and transportation, storage, and densification costs. Monte Carlo simulation was used to estimate the probability distribution of costs under alternative assumptions on key parameters whose values vary widely in the literature. For a facility producing 0.189 $\mathrm{hm}^3\,\mathrm{y}^{-1}$ of ethanol, marginal feedstock cost was estimated at $\$60\,\mathrm{Mg}^{-1}$ ($\$200\,\mathrm{m}^{-3}$ ethanol) for the more-intensive harvest method and $\$72\,\mathrm{Mg}^{-1}$ ($\$210\,\mathrm{m}^{-3}$) for the less-intensive method. Costs were greater than $\$68\,\mathrm{Mg}^{-1}$ ($\$240\,\mathrm{m}^{-3}$) for a facility producing $>0.757\,\mathrm{hm}^3\,\mathrm{y}^{-1}$ ethanol under the more-intensive method, and greater than $\$93\,\mathrm{Mg}^{-1}$ ($\$320\,\mathrm{m}^{-3}$) for the less-intensive method. Monte Carlo simulation estimated a mean marginal cost of $\$57\,\mathrm{Mg}^{-1}$ ($\$69\,\mathrm{Mg}^{-3}$ under the less-intensive harvest method) for 0.189 hm^3 ethanol output, with a \$12 (\$10) standard deviation. Costs were found to be at or below $\$68\,\mathrm{Mg}^{-1}$ 90 percent of the time ($\$78\,\mathrm{Mg}^{-1}$ for the less-intensive method). A $\$12\,\mathrm{Mg}^{-1}$ standard deviation in stover cost would result in a $\$40\,\mathrm{m}^{-3}$ swing in ethanol cost.

08/02851 The emergence and troubled growth of a 'biopower' innovation system in Sweden

Jacobsson, S. *Energy Policy*, 2008, 36, (4), 1491–1508.

Biopower, i.e. production of power using biomass, has a tremendous potential to deliver CO_2 neutral energy in the Nordic countries. This paper analyses the evolution of a biopower innovation system in Sweden where particular attention is given to current driving forces and obstacles to a large-scale diffusion of biopower. In the 1980s and 1990s, this innovation system went through a successful 'formative phase' in which all the constituent components of the 'infant' system emerged. With the introduction of green certificates and emission trading rights, incentives were created that were large enough to shift the system into a 'growth phase', where the extensive district heating system and voluminous production in the paper and pulp industry can be used to produce power on a large scale in CHP plants. An investment boom is now underway and output of biopower is rapidly growing. Yet, there are still substantial obstacles to a realization of the full potential of biopower. Three of these are outlined and an associated set of policy challenges are specified.

08/02852 Toward an optimal U.S. ethanol fuel subsidy

Vedenov, D. and Wetzstein, M. *Energy Economics*, 2008, 30, (5), 2073–2090.

Enhanced environmental quality, fuel security, and economic development along with reduced prices of ethanol–gasoline blends are often used as justifications for the US federal excise tax exemption on ethanol fuels. However, the possible effect of increased overall consumption of fuel in response to lower total price, mitigating the environmental and fuel security benefits, are generally not considered. Taking this price response into account, the optimal US ethanol subsidy is derived. Estimated values of the optimal subsidy reveal that the subsidy's environmental and security benefits are questionable. However, positive environmental and security benefits from the ethanol tax-exemption subsidy may be obtained if the subsidy is combined with an increase in the excise tax on gasoline.

08/02853 Virtual biofuels – a cheaper, better, faster alternative?

Saunders, H. D. *Energy Policy*, 2008, 36, (4), 1247–1250.

This viewpoint article offers the proposition that purpose-grown biomass buried in landfills constitutes a 'virtual' biofuel that is more practical, economic, and immediate than the use of actual biofuels from cellulosics. While not a permanent solution, it may be a useful bridge to the hoped-for era of actual biofuels prior to the time technology for economically converting cellulosics to actual liquid biofuels is realized.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

08/02854 A new approach to compute heat transfer of ground-coupled envelope in building thermal simulation software

Xie, X. *et al. Energy and Buildings*, 2008, 40, (4), 476–485.

This study presents a new approach to compute the heat transfer of ground-coupled envelope quickly and correctly which is suitable for implementation into building thermal simulation software. The heat transfer process is decomposed into three processes which are controlled by ground-coupled envelope surface temperature, outdoor ground surface temperature and the temperature difference of ground-coupled envelope surfaces. The three processes are computed by computing one-dimensional equivalent slab, simplifying outdoor temperature as harmonic and computing one-dimensional extra partition wall. Validation indicates that the heat flux of ground-coupled envelope surface computed by the new approach is very close to that computed by finite difference method (FDM) under unsteady boundary conditions. The computing time is much less than that with FDM.

08/02855 A semi-implicit numerical scheme for a transient two-fluid three-field model on an unstructured grid

Jeong, J. J. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 597–606.

A three-dimensional (3D) unstructured hydrodynamic solver for transient two-phase flows has been developed for a 3D component of a nuclear system code and a component-scale analysis tool. A two-fluid three-field model is used for the two-phase flows. The three fields represent a continuous liquid, an entrained liquid, and a vapour field. An unstructured grid is adopted for realistic simulations of the flows in a complicated geometry. The semi-implicit implicit continuous-fluid Eulerian (ICE) numerical scheme has been adapted for an unstructured non-staggered grid. This paper presents the numerical method and the preliminary results of the calculations. The results show that the modified ICE scheme is robust and predicts the phase changes and the flow transitions due to a boiling and a flashing very well.

08/02856 A simple formula for estimating global solar radiation in central arid deserts of Iran

Sabziparvar, A. A. *Renewable Energy*, 2008, 33, (5), 1002–1010.

Over the last two decades, using simple radiation models has been an interesting task to estimate daily solar radiation in arid and semi-arid deserts such as those in Iran, where the number of solar observation sites is poor. In Iran, most of the models used so far, have been validated for a few specific locations based on short-term solar observations. In this work, three different radiation models (Sabbagh, Paltridge, Daneshyar) have been revised to predict the climatology of monthly average daily solar radiation on horizontal surfaces in various cities in central arid deserts of Iran. The modifications are made by the inclusion of altitude, monthly total number of dusty days and seasonal variation of Sun–Earth distance. A new height-dependent formula is proposed based on MBE, MABE, MPE and RMSE statistical analysis. It is shown that the revised Sabbagh method can be a good estimator for the prediction of global solar radiation in arid and semi-arid deserts with an average error of less than 2%, that performs a more accurate prediction than those in the previous studies. The required data for the suggested method are usually available in most meteorological sites. For the locations, where some of the input data are not reported, an alternative approach is presented.

08/02857 An applied artificial intelligence approach towards assessing building performance simulation tools

Yezioro, A. *et al. Energy and Buildings*, 2008, 40, (4), 612–620.

With the development of modern computer technology, a large amount of building energy simulation tools is available in the market. When choosing which simulation tool to use in a project, the user must consider the tool's accuracy and reliability, considering the building information they have at hand, which will serve as input for the tool. This paper presents an approach towards assessing building performance simulation results to actual measurements, using artificial neural networks (ANN) for predicting building energy performance. Training and testing of the ANN were carried out with energy consumption data acquired for 1 week in the case building called the Solar House. The predicted results show a good fitness with the mathematical model with a mean absolute error of 0.9%. Moreover, four building simulation tools were selected in this study in order to compare their results with the ANN predicted energy consumption: Energy_10, Green Building Studio web tool, eQuest and EnergyPlus. The results showed that the more detailed simulation tools have the best simulation performance in terms of heating and cooling electricity consumption within 3% of mean absolute error.

08/02858 An approach to the exergy analysis of photosynthesis

Petela, R. *Solar Energy*, 2008, 82, (4), 311–328.

Photosynthesis is a complex endothermic process involving two kinds of matter; substance and radiation. This threefold study consists of: (1) an energy analysis (the energy conservation equation is developed to estimate the energy effects of the process); (2) entropy analysis (the changes of entropy are used to estimate the irreversibility of the component processes); and (3) exergy analysis (developed for thermodynamic evaluation of both kinds of matter). A simplified mathematical diffusive model of photosynthesis (controlled by diffusion of gases) is used to analyse key aspects of the problem. The corresponding terms of energy and exergy equations are compared and discussed. Photosynthesis is a highly irreversible process. In the calculation example the irreversibility loss is 97.4%. This increases slightly together with increasing temperatures of leaf and environment. On the contrary, the energy equation does not show any loss due to irreversibility. In the calculation example for the presented model, the exergy degree of perfection for photosynthesis is 2.61% and the energy degree of perfection is 35.4%. The rate of sugar production is $3.21 \times 10^{-9}\,\mathrm{kmol\,m^{-2}\,s^{-1}}$. Heat transferred to the environment by radiation and convection is respectively 6.4% and 65.3%. The exergies of the radiant and convective heat are 0.003% and zero, respectively. The impacts on several output parameters (e.g. leaf temperature, sugar rate, degrees of perfection, etc.) were determined: the effect of varying input conditions (e.g. environmental temperature and humidity, leaf absorptivity, intensity of solar radiation, coefficient of convective heat transfer, and CO_2 concentration). Some possibilities for further developing the exergy analysis are discussed.

08/02859 Capital-energy substitution and shifts in factor demand: a meta-analysis

Koetse, M. J. *et al. Energy Economics*, 2008, 30, (5), 2236–2251.

This paper presents a meta-analysis of capital-energy substitution elasticities. The authors distinguish between Morishima elasticities, which measure technological substitution potential, and cross-price elasticities, which measure actual percentage changes in capital demand in response to energy price changes. It is estimated that a meta-regression model with separate coefficients for the two elasticity samples. The results show that the heterogeneity in both the cross-price and Morishima elasticity samples can to a large extent be explained by study differences in, among others, model specification, data characteristics, region and time period. Controlling for potential sources of misspecification and aggregation bias the authors subsequently calculate short- and long-run elasticities for different regions and time periods. The resulting elasticities show that technological substitution potential is large, especially in the long run for North America. Despite substantial differences across regions and time periods, the estimated cross-price elasticities suggest capital-energy substitutability without exception.

08/02860 Combined simulation of central HVAC systems with a whole-building hygrothermal model

Barbosa, R.M. and Mendes, M. *Energy and Buildings*, 2008, 40, (3), 176–288.

Due to the lack of building simulation programs that can simulate in details the combined heat, vapour and liquid transfer in porous elements and the heating, ventilation and air-conditioning (HVAC) systems, a generic and flexible computational algorithm has been elaborated in order to integrate models for both HVAC systems and multi-zone building hygrothermal model. In the algorithm, models for the primary components (chiller, cooling tower, primary pumps and condensation pumps) and for the secondary components (cooling and dehumidifying coil, humidifier, fan and mixing box) have been presented. Those mathematical models have been integrated into a whole-building simulation model, allowing to perform whole-building hygrothermal simulation combined to HVAC systems and plant simulation. The building hygrothermal model is based on the simultaneous calculation of temperature and moisture content distributions within the porous envelope taking into account both vapour diffusion and capillary migration. First, results are presented for a multi-zone building to show the usability of the proposed algorithm. Then, the analysis of the influence of the adsorption and desorption phenomena on the calculation of thermal loads and energy consumption is presented, showing that the disregard of moisture may oversize the HVAC system in 13% and underestimate the cooling energy consumption in 4% for the case study defined in this paper.

08/02861 Detailed analysis of (n,p) and (n,a) cross sections in the EAF-2007 and TALYS-generated libraries

Forrest, R. A. *et al. Fusion Engineering and Design*, 2008, 83, (4), 634–643.

Large cross-section libraries, such as EAF-2007 used for activation calculations, need to be validated. A traditional approach employs simple systematic formulae based on experimental data and derived at energies such as 14.5 MeV. Such systematics are also used for renormalization of cross sections during library preparation. This approach is gradually being replaced by using results of sophisticated nuclear model calculations. As the energy range of EAF libraries has expanded from 20 to 60 MeV an additional approach is required and the method of 'statistical analysis of cross sections' (SACS) has proved to be useful. SACS analyses are carried out for the important charged particle reactions (n,p) and (n,α) in the EAF-2007 and TALYS-6 libraries. TALYS-6 is a calculational library generated by the TALYS model code Version 0.72. SACS considers various reaction statistics such as $\sigma_{\max}$, $E_{\max}$ and $\Delta_{1/2}$ and plots scatter plots against a parameter such as the asymmetry (s). Trend lines using simple algebraic formulae can be fitted to the data and points discrepant from the trends correspond to reactions that require improvement. A new observation is a 'step' in the $\Delta_{1/2}(s)$ plot for (n,p) reactions and this has been interpreted as due to competition between (n,p) and (n,n′p) reaction channels. Equations for the various trend curves for EAF-2007 are given.

08/02862 Development of two-colour pyroreflectometry technique for temperature monitoring of tungsten plasma facing components

Hernandez, D. *et al. Fusion Engineering and Design*, 2008, 83, (4), 672–679.

For reflective metals like tungsten used in certain plasma facing components of fusion devices, the black body or grey assumption is clearly impossible. For optical measurements of their temperature under heat fluxes coming from the plasma, knowledge of their thermo-optical properties is required. The two-colour pyroreflectometry technique presented in this paper is a potential solution to measure '*in situ*' the temperature on tungsten above 600 °C. The main assumption of the technique is that the indicatrix of reflection does not vary within the narrow wavelength range used. With this technique, the diffusivity factor η_d is introduced to determine the convergence temperature T^* that is assumed to be equal to the true temperature T. Aim of the study presented in this paper was to validate the two-colour pyroreflectometry technique for tungsten plasma components and to develop and test dedicated systems for plasma facing components application. The validation was performed in two steps: (a) comparison of the temperature measured by the proposed technique with thermocouple; (b); comparison of the diffusion factor η_d measurements by the proposed technique with direct measurements using multi-directional reflectometer. Finally, two specific optical probes allowing remote measurements (in the range 0.5–2 m) were developed and successfully tested at a high heat flux facility dedicated to the thermal fatigue of plasma facing components using electron beam scanning, this facility is considered thermally and geometrically relevant for fusion environment. The results obtained demonstrated the suitability of the two-colour pyroreflectometry technique to determine the true temperature on tungsten plasma facing components and to detect possible modifications of its surface properties through the measurements of the diffusivity factor. However, an ultimate validation in real fusion environment including parasitic signal from reflections from other locations or bremsstrahlung from plasma is still necessary before routinely using such a diagnostic in a fusion machine.

08/02863 Dynamic behavior of surface film on $LiCoO_2$ thin film electrode

Matsui, M. *et al. Journal of Power Sources*, 2008, 177, (1), 184–193.

Electrochemical oxidation behaviour of non-aqueous electrolytes on $LiCoO_2$ thin film electrodes were investigated by *in situ* polarization modulation Fourier transform infrared (PM-FTIR) spectroscopy, atomic force microscopy and X-ray photoelectron spectroscopy (XPS). $LiCoO_2$ thin film electrode on gold substrate was prepared by rf-sputtering method. *In situ* PM-FTIR spectra were obtained at various electrode potentials during cyclic voltammetry measurement between 3.5 V vs. Li/Li^+ and 4.2 V vs. Li/Li^+. During anodic polarization, oxidation of non-aqueous electrolyte was observed, and oxidized products remained on the electrode at the potential higher than 3.75 V vs. Li/Li^+ as a surface film. During cathodic polarization, the stripping of the surface film was observed at the potential lower than 3.9 V vs. Li/Li^+. Depth profile of XPS also showed that more organic surface film remained on charged $LiCoO_2$ than that on discharged one. AFM images of charged and discharged electrodes showed that some decomposed products deposited on charged electrode and disappeared from the surface of discharged one. These results indicate that the surface film on $LiCoO_2$ is not so stable.

08/02864 Effect of aspect ratio on entropy generation in a rectangular cavity with differentially heated vertical walls

Ilis, G. G. *et al. International Communications in Heat and Mass*, 2008, 35, (6), 696–703.

In the present study, entropy generation in rectangular cavities with the same area but different aspect ratios is numerically investigated. The vertical walls of the cavities are at different constant temperatures while the horizontal walls are adiabatic. Heat transfer between vertical walls occurs by laminar natural convection. Based on the obtained dimensionless velocity and temperature values, the distributions of local entropy generation due to heat transfer and fluid friction, the local Bejan number and local entropy generation number are determined and related maps are plotted. The variation of the total entropy generation and average Bejan number for the whole cavity volume at different aspect ratios for different values of the Rayleigh number and irreversibility distribution ratio are also evaluated. It is found that for a cavity with high value of Rayleigh number (i.e. $Ra = 10^5$), the total entropy generation due to fluid friction and total entropy generation number increase with increasing aspect ratio, attain a maximum and then decrease. The present results are compared with reported solutions and excellent agreement is observed. The study is performed for $10^2 < Ra < 10^5$, $10^{-4} < \phi < 10^{-2}$, and $Pr = 0.7$.

08/02865 Electrical properties of Al-doped oxyapatites at intermediate temperature

Chefi, S. *et al. Journal of Power Sources*, 2008, 177, (2), 464–469.

In order to obtain acceptable performances in SOFC, relatively high operating temperatures (~850–1000 °C) are required. That is mainly due to the low ionic conductivity of YSZ electrolyte. These temperature conditions are at the origin of the cell degradation, which justify the search for alternative electrolytes presenting the same performances but at lower temperature (~800 °C). It is in this context that the oxyapatites of general formula $La_{10-x}Si_{6->y}Al_yO_{27-3x/2-y/2}$ ($x = 0, 0.67$; $y = 0.25, 0.50, 0.75$) are studied in this work. The solid solutions are prepared by sintering the oxide powders at 1600 °C. All samples have shown a hexagonal structure with an increase in the cell parameters with the aluminium content. Electrical properties are determined by impedance spectroscopy between 169 and 790 °C. The results are treated by separating the bulk and grain boundary conductivities between 169 and 500 °C and in the form of total (bulk + grain boundary) conductivity between 500 and 790 °C. The respective influences of the activation energy and the pre-exponential factor on conductivity are analysed. Activation energies are about 0.65 eV suggesting an interstitial mechanism. No variation of conductivity is observed with the oxygen partial pressure. Finally, $La_{10}Si_{5.5}Al_{0.5}O_{26.75}$ shows conductivity higher than that of YSZ at intermediate temperature.

08/02866 Electron microscopy techniques for the analysis of the polymer electrolyte distribution in proton exchange membrane fuel cells

Scheiba, F. *et al. Journal of Power Sources*, 2008, 177, (2), 273–280.

The polymer electrolyte distribution in proton exchange membrane fuel cells (PEMFC) electrodes plays an important role for the catalyst utilization and various transport processes in the electrode. Moreover, its influence on the transport processes is not only limited to proton transport but it may also affect gas transport, electron conductivity and water management of the cell. However, experimental techniques to study the polymer electrolyte distribution are scarce. In this paper, various approaches are presented based on scanning electron microscopy (SEM) and transmission electron microscopy (TEM) to characterize the polymer electrolyte distribution. The methods presented include staining of the polymer electrolyte with heavy metal ions, energy dispersive X-ray (EDX) mapping and energy filtered imaging (EFI). Their use for the analysis of the polymer electrolyte distribution and electrode structure will be presented and current limitations of these techniques will be discussed.

08/02867 Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks

Narayan, P. K. and Smyth, R. *Energy Economics*, 2008, 30, (5), 2331–2341.

This paper examines the relationship between capital formation, energy consumption and real gross domestic product (GDP) in a panel of the Group of Seven leading industrialized countries (G7 countries) using panel unit root, panel cointegration, Granger causality and long-run structural estimation. It is found that capital formation, energy consumption and real GDP are cointegrated and that capital formation and energy consumption Granger cause real GDP positively in the long run. The authors find that a 1% increase in energy consumption increases real GDP by 0.12–0.39%, while a 1% increase in capital formation increases real GDP by 0.1–0.28%.

08/02868 Enhanced electrochemical properties of a Si-based anode using an electrochemically active polyamide imide binder

Choi, N.-S. *et al. Journal of Power Sources*, 2008, 177, (2), 590–594.

Polyamide imide (PAI), one of the classes of copolyimides containing both high mechanical properties and processibility, is used as a polymeric binder of a Si particulate electrode. The initial coulombic efficiency is improved from 28.9% (Si-PVdF) to 74.9% (Si-PAI) by introducing a PAI binder into a Si-based electrode. Variations in thickness measured at various states of charge (SOCs) and depths of discharge (DODs) indicate that the PAI binder is a much more effective restraint on volume expansion in active Si materials during the charging process than poly(vinylidene fluoride) (PVdF) binder. The discharge capacity of Si-PAI electrodes is approximately 1700 mAh g^{-1} after 20 cycles, which is attributed to the excellent maintenance of an electrical-conducting network during cycling.

08/02869 Entropy generation through combined non-grey gas radiation and forced convection between two parallel plates

Nejma, F. B. *et al. Energy*, 2008, 33, (7), 1169–1178.

The current study presents a numerical computation of combined gas radiation and forced convection through two parallel plates. A laminar flow of a temperature-dependent and non-grey gas in the entrance region of the channel was investigated. Over-heated water vapour was chosen as a gas because of its large absorption bands. Some special attention was given to entropy generation and its dependence on geometrical and thermodynamic parameters. The radiative part of the study was solved using the 'Ray Tracing' method through S_4 directions, associated with the 'statistical narrow band correlated-k' (SNBCK) model. The temperature fields were used to calculate the distributions of local and global entropy generation.

08/02870 Experimental and numerical analysis of stratified turbulent V-shaped flames

Robin, V. *et al. Combustion and Flame*, 2008, 153, (1–2), 288–315.

The present paper is devoted to (i) the experimental study of partially premixed combustion with strong equivalence ratio gradients, i.e. stratification of the reactive mixture and (ii) the numerical modelling of turbulent reactive flows in such situations where reactants are far from being ideally premixed. From a practical point of view, at least two variables are necessary to describe the local thermochemistry in this case: the mixture fraction ξ and the fuel mass fraction Y_f are considered to represent respectively the local composition of the fresh mixture and the progress of chemical reactions. From the experimental point of view, the use of simultaneous imaging techniques allows the evaluation of both variables in terms of fuel mole fraction and temperature. In the present study, a combined acetone PLIF measurement and Rayleigh scattering technique is used. The influence of temperature on the fluorescence signal is corrected thanks to the knowledge of the local temperature through Rayleigh scattering measurements. Conversely, the influence of the acetone Rayleigh cross section can be evaluated with the local value of acetone mole fraction. Using the iterative procedure already described by Degardin *et al.*, the corrected fuel mole fraction and temperature fields can be obtained. Here the particular flow configuration under study is a stratified turbulent V-shaped flame of methane and air. In a first step of the analysis, the optical diagnostics are used to perform a detailed investigation of the flame thickness with a special emphasis on the influence of partially premixed conditions. In a second step, experimental data are used to evaluate the LW-P model as defined by Robin *et al.* to calculate turbulent reactive flows with partially premixed conditions based on an earlier analysis by Libby and Williams. The closure problem raised by the mean scalar dissipation terms is also discussed in the light of experimental results. Since the usual closures for nonreactive flows are expected to be unsuitable to describe reactive scalar fluctuations decay a new modelling proposal based on the recent developments of Mura *et al.* is used. After a preliminary validation step where numerical predictions of the flame mean quantities are compared successfully with the experimental database, numerical simulations are used to describe the mean structure of stratified flames and in particular the evolution of the mean chemical reaction rate for different partially premixed conditions.

08/02871 Forecasting crude oil price with an EMD-based neural network ensemble learning paradigm

Yu, L. *et al. Energy Economics*, 2008, 30, (5), 2623–2635.

In this study, an empirical mode decomposition (EMD) based neural network ensemble learning paradigm is proposed for world crude oil spot price forecasting. For this purpose, the original crude oil spot price series were first decomposed into a finite, and often small, number of intrinsic mode functions (IMFs). Then a three-layer feed-forward neural network model was used to model each of the extracted IMFs, so that the tendencies of these IMFs could be accurately predicted. Finally, the prediction results of all IMFs are combined with an adaptive linear neural network, to formulate an ensemble output for the original crude oil price series. For verification and testing, two main crude oil price series, West Texas Intermediate crude oil spot price and Brent crude oil spot price, are used to test the effectiveness of the proposed EMD-based neural network ensemble learning methodology. Empirical results obtained demonstrate attractiveness of the proposed EMD-based neural network ensemble learning paradigm.

08/02872 Forecasting of a ground-coupled heat pump performance using neural networks with statistical data weighting pre-processing

Esen, H. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 431–441.

The objective of this work is to improve the performance of an artificial neural network (ANN) with a statistical weighted pre-processing (SWP) method to learn to predict ground source heat pump systems with the minimum data set. Experimental studies were completed to obtain training and test data. Air temperatures entering/leaving condenser unit, water-antifreeze solution entering/leaving the horizontal ground heat exchangers and ground temperatures (1 and 2 m) were used as input layer, while the output is coefficient of performance of system. Some statistical methods, such as the root-mean squared (RMS), the coefficient of multiple determinations (R^2) and the coefficient of variation (COV) is used to compare predicted and actual values for model validation. It is found that RMS value is 0.074, R^2 value is 0.9999 and cov value is 2.22 for SCG6 algorithm of only ANN structure. It is also found that RMS value is 0.002, R^2 value is 0.9999 and COV value is 0.076 for SCG6 algorithm of SWP-ANN structure. The simulation results show that the SWP based networks can be used an alternative way in these systems. Therefore, instead of limited experimental data found in literature, faster and simpler solutions are obtained using hybridized structures such as SWP-ANN.

08/02873 HOLIGILM: hollow light guide interior illumination method – an analytic calculation approach for cylindrical light-tubes

Kocifaj, M. *et al. Solar Energy*, 2008, 82, (3), 247–259.

A physical model for interior illuminance calculation HOLIGILM applied to cylindrical skylights was developed. Based on the ray-tracing between the diffuser of a tubular skylight and the sky vault including the Sun, the light transmission coefficient of the cover dome and of the interior diffuser with the high light-guide reflection, as well as taking into account the geometry of the interior, the resulting illuminance of the working plane can be analysed. As the model is strictly physical it allows to study influences of optical properties of tubular skylights (dome, tube and diffuser) on the interior daylight illuminance distribution specifying the luminance distribution on the hollow light-guide diffuser. The standard sky luminance distributions adopted ISO 15469:2004 and the new solar luminance and constant were included into the evaluation concept of tubular skylight. In addition to the original formulae some practical examples of the predicted illuminance on the working plane are also presented in this paper.

08/02874 Implications of electronic short circuiting in plasma sprayed solid oxide fuel cells on electrode performance evaluation by electrochemical impedance spectroscopy

White, B. D. and Kesler, O. *Journal of Power Sources*, 2008, 177, (1), 104–110.

Electronic short circuiting of the electrolyte in a solid oxide fuel cell (SOFC) arising from flaws in the plasma spray fabrication process has been found to have a significant effect on the perceived performance of the electrodes, as evaluated by electrochemical impedance spectroscopy (EIS). The presence of a short circuit has been found to lead to the underestimation of the electrode polarization resistance (R_p) and hence an overestimation of electrode performance. The effect is particularly noticeable when electrolyte resistance is relatively high, for example during low to intermediate temperature operation, leading to an obvious deviation from the expected Arrhenius-type temperature dependence of R_p. A method is developed for determining the real electrode performance from measurements of various cell properties, and strategies for eliminating the occurrence of short circuiting in plasma sprayed cells are identified.

08/02875 Influence of mathematical models in design of PV-Diesel systems

Dufo-López, R. and Bernal-Agustín, J. L. *Energy Conversion and Management*, 2008, 49, (4), 820–831.

This paper presents a study of the influence of mathematical models in the optimal design of PV-Diesel systems. For this purpose, a design tool developed by the authors, which allows obtaining the most cost effective design of a PV-Diesel system through the genetic algorithm technique, has been used. The mathematical models of some elements of the hybrid system have been improved in comparison to those usually employed in hybrid systems design programs. Furthermore, a more complete general control strategy has been developed, one that also takes into account more characteristics than those usually considered in this kind of design. Several designs have been made, evaluating the effect on the results of the different mathematical models and the novel strategy that can be considered.

08/02876 Kinetic modeling of the hydrotreatment of light cycle oil and heavy gas oil using the structural contributions approach

Froment, G. F. *et al. Catalysis Today*, 2008, 130, (2–4), 446–454.

The kinetics of the hydrodesulfurization of light cycle oil (LCO) and heavy gas oil (HGO) over a CoMo/Al_2O_3 catalyst were investigated in a perfectly mixed flow reactor with stationary basket of the Robinson-Mahoney type at temperatures of 330, 310 and 290 °C, H_2/HC molar ratios of 2.8, 3.6 and 7.2 and a pressure of 65 bar. Hougen-Watson type rate equations were derived for the conversion of dibenzothiophene, substituted (di)benzothiophene and their products. To avoid having to deal with a huge number of model parameters, a methodology based upon structural contributions was applied. In the absence of own kinetic data on key components a number of kinetic and adsorption parameters were taken from published work on a very similar catalyst. For a given value of H_2/HC only a small number of experiments was required to determine the value of the very complex denominators DEN_σ and DEN_t appearing in the rate equations for the hydrodesulfurization of LCO and of HGO and of their evolution with the conversion of the feedstock. With the rate equations constructed in this way the calculated total conversion of DBT, its conversion into biphenyl and into cyclohexylbenzene were in excellent agreement with the experimental values.

08/02877 *N*-Methyl-(*n*-butyl)pyrrolidinium bis(trifluoromethanesulfonyl)imide-LiTFSI–poly(ethylene glycol) dimethyl ether mixture as a Li/S cell electrolyte

Shin, J. H. and Cairns, E. J. *Journal of Power Sources*, 2008, 177, (2), 537–545.

In this paper, the authors have characterized a ternary mixture of *N*-methyl-(*n*-butyl)pyrrolidinium bis(trifluoromethanesulfonyl)imide (PYR14TFSI) + 0.5 M LiTFSI + *y* poly(ethylene glycol) dimethyl ether (PEGDME) (y = kg PEGDME/kg PYR14TFSI) as an electrolyte in Li metal/S cells. The presence of PYR14TFSI in the mixture resulted in a significant improvement of the thermal stability and the ionic conductivity (σ) of the mixture with increasing PEGDME contents (for example, $\sigma = 4.2 \times 10^{-3}\,S\,cm^{-1}$ at 29 °C for $y = 2.0$). These improvements are most significant at low temperatures, which is probably due to a lowering of the viscosity of the mixture with higher amounts of PEGDME. It is found that the mixture has good compatibility with respect to Li metal as demonstrated by time-dependent interfacial impedance and galvanostatic Li stripping/deposition measurements. It was found that a Li/S cell with PYR14TFSI = 0.5 M LiTFSI = *y* PEGDME ($y = 2.0$) can deliver about 1300 mAh g^{-1}-sulfur at 0.054 mA cm^{-2} at ambient temperature at the first cycle. A better charge/discharge cyclability of the Li/S cell in PYR_{14}TFSI + 0.5 M LiTFSI + *y* PEGDME was found at higher PEGDME contents, and a Li/S cell with the mixture having $y = 2.0$ exhibited a capacity fading rate of 0.42% per cycle over 100 cycles at 0.054 mA cm^{-2} at 40 °C. Consequently the PYR14TFSI + LiTFSI + PEGDME mixture is a promising electrolyte for Li/S cells.

08/02878 Nano-Sn/hard carbon composite anode material with high-initial coulombic efficiency

Guo, B. *et al. Journal of Power Sources*, 2008, 177, (1), 205–210.

Nanoscaled tin (Sn) particles were embedded in the mesopores of hard carbon spherules (HCS) to form a composite anode material for lithium ion batteries. The structure of the obtained composite was characterized by X-ray diffraction (XRD) and the electrochemical performances were evaluated by galvanostatic cycling and cyclic voltammetry. It is found that embedding Sn nanoparticles into HCS not only results in a composite material with high-lithium storage capacity and capacity retention, but also increases the initial coulombic efficiency of the composite. Based on the infrared spectroscopic analysis, the enhanced initial coulombic efficiency is attributed to the nano-tin-induced decomposition of the $ROCO_2Li$ species in the solid electrolyte interphase (SEI) layer.

08/02879 New genetic algorithms (GA) to optimize PWR reactors – part I: loading pattern and burnable poison placement optimization techniques for PWRs

Alim, F. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 93–112.

The objective of this study was to develop a unique scientific methodology as well as a practical tool for designing the loading pattern (LP) and burnable poison (BP) pattern for a given pressurized water reactor (PWR) core. Because of the large number of possible combinations for the fuel assembly (FA) loading in the core, the design of the core configuration is a complex optimization problem. It requires finding an optimal FA arrangement and corresponding BP placement design that will achieve maximum cycle length while satisfying the safety constraints. To solve this optimization problem, a core reload optimization package, genetic algorithm reactor code optimization (GARCO) code is developed. This code is applicable for all types of PWR cores having different geometries and designs with an unlimited number of FA types in the inventory. GARCO has three modes: the user can optimize the core configuration (LP pattern) with or without BPs in the first mode; the second mode is the optimization of BP placement in the core and the last mode is the user can optimize LP and BP placements simultaneously in mode 3. In this study, the first mode finds the optimal LPs using the haling power depletion method for placing BPs in the core. The second mode, which depletes the core accurately, places BPs in the selected optimum LP pattern. This methodology is applied only to the TMI-1 PWR. However, the improved mode 1 GA option was applied to both the VVER-1000 and the TMI-1 to demonstrate and verify the advantages of the new enhancements in optimizing the LP pattern only. The 'Moby-Dick' code is used as reactor physics code for VVER-1000 analysis in this research. The SIMULATE-3 code, which is an advanced two-group nodal code, is used to analyse the TMI-1. The libraries of the BP designs used in SIMULATE-3 in this study were produced by Yilmaz (2005).

08/02880 New genetic algorithms (GA) to optimize PWR reactors – part II: simultaneous optimization of loading pattern and burnable poison placement for the TMI-1 reactor

Alim, F. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 113–120.

In this paper, the genetic algorithm reactor code optimization–Pennsylvania State University (GARCO–PSU) code simultaneously optimizes the core loading pattern (LP) and the burnable poison (BP) placement in a pressurized water reactor (PWR). The LP optimization and BP placement optimization are interconnected, but it is difficult to solve the combined problem due to its large size. Separating the problem into two sequential steps provides a practical way to solve the problem. However, the result of this method alone may not develop the real optimal solution. GARCO–PSU achieves solving the LP optimization and BP placement optimization simultaneously by developing an innovative genetic algorithm (GA). The classical representation of the genotype has been modified to incorporate in-core fuel management basic knowledge. GARCO has three modes; the first mode optimizes the LP only, the second mode optimizes the LP and BP placement in sequence. The third mode, which optimizes the LP and BP placement simultaneously, is described in this paper. GARCO, as stated in Part I, can be applied to all types of PWR core structures having different geometries with an unlimited number of fuel assembly types in the inventory.

08/02881 New genetic algorithms (GA) to optimize PWR reactors – part III: the Haling power depletion method for in-core fuel management analysis

Alim, F. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 121–131.

The Haling power distribution (HPD) has been applied in a unique process to greatly accelerate the in-core fuel management optimization calculations. These calculations involve; the arrangement of fuel assemblies (FAs) and the placement of burnable poisons (BPs) in the fresh FAs. The HPD deals only with the arrangement of FAs. The purpose of this paper is to describe past uses of the HPD, provide an example selected from many similar calculations to explain why and how it can be used, and also to show its effectiveness as a filter in the GARCO GA code. The genetic algorithm reactor core optimization (GARCO) is an innovative GA code that was developed by modifying the classical representation of the genotype and GA operators. A reactor physics code evaluates the LPs in the population using the HPD Method, which rapidly depletes the core in a single depletion step with a constant power distribution. The HPD is used basically in GARCO as a filter to eliminate invalid LPs created by the genetic operators, to choose a reference LP for BP optimization, and to create an initial population for simultaneous optimization of the LP and BP placement into the core. The accurate depletion calculation of the LP with BPs is done with the coupled lattice and reactor physics CASMO-4/SIMULATE3 package. However, the fact that these codes validate safety of the core with the added BP placement design also validates the use of the HPD method. The calculations are applied to the TMI-1 core as an example PWR providing concrete results.

08/02882 Nucleate boiling of FC-72 and HFE-7100 on porous graphite at different orientations and liquid subcooling

El-Genk, M. S. and Parker, J. L. *Energy Conversion and Management*, 2008, 49, (4), 733–750.

FC-72 and HFE-7100 dielectric liquids are favoured for immersion cooling applications of computer chips. This paper reports the results of series of experiments that systematically investigated nucleate boiling of both FC-72 and HFE-710 on a plain porous graphite surface measuring 10 × 10 mm. The obtained values of the nucleate boiling heat transfer coefficient and critical heat flux (CHF), at different surface orientations, 0° (upward facing) to 180° and liquid subcooling up to 30 K are compared. In addition to the absence of temperature excursions prior to boiling incipience, the CHF increases linearly with increased liquid subcooling but at a rate that is 10% higher for HFE-7100 than that for FC-72. The CHF for HFE-7100 is typically 10% to 15% higher than that for FC-72, however, the maximum nucleate boiling heat transfer coefficient, occurring at or near the end of the fully developed nucleate boiling region, is 57% higher for FC-72 than that for HFE-7100 and increases also linearly with increased liquid subcooling. The CHF correlation developed accounts for the effects of surface characteristics (smooth, porous, or micro-porous), liquid properties and subcooling, and surface inclination and fits present and reported values by other investigators to within ±10%.

08/02883 Numerical modeling of NO_x reduction using pyrolysis products from biomass-based materials

Pisupati, S. V. and Bhalla, S. *Biomass and Bioenergy*, 2008, 32, (2), 146–154.

Pyrolysis products of biomass (bio-oils) have been shown to cause a reduction in NO_x emissions when used as reburn fuel in combustion systems. When these bio-oils are processed with lime, calcium is ion-exchanged and the product is called BioLime^{TM}. BioLime, when introduced into a combustion chamber, causes oils to pyrolyse and reduce NO_x emissions through reburn mechanisms while simultaneously causing Ca to react with SO_2. Thus NO_x and SO_2 emissions are reduced at the same time. The devolatilization rates of two biomass-based materials were studied using TGA and were related to the yield of pyrolysis gases and char during flash pyrolysis. Numerical simulations using CHEMKIN to model NO reduction through homogeneous gas phase reactions were reported. The numerical predictions were then compared to NO_x emission levels from experiments in a down-fired combustor to validate the model. A difference in NO reduction was observed by use of different bio-oils under similar operating conditions. This is believed to be due to the difference in yield of flash pyrolysis products of bio-oils. Also, different pyrolysis gases have different NO_x reduction potentials. Knowledge of the relative contribution of pyrolysis gases in NO reduction will help choose a feedstock of biomass that will aid in increasing the yield of the desired species. A parametric analysis was done using the model to study the effect of varying concentrations of hydrocarbons, CO_2, CO, and H_2, and the results were then verified using a flow reactor. The analysis showed that hydrocarbons were mainly responsible for causing reduction in emissions of NO, whereas CO_2, CO, and H_2 have very little effect on NO reduction.

08/02884 Numerical simulation of flow in a natural draft wet cooling tower – the effect of radial thermofluid fields

Williamson, N. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 178–189.

This paper presents a two-dimensional axisymmetric two-phase simulation of the heat and mass transfer inside a natural draft wet cooling tower with particular emphasis on determining the extent of the non-uniformities across the tower. The water droplets in the spray and rain zones are represented with droplet trajectories written in Lagrangian form. The heat and mass transfer in the fill is represented using source terms implemented with Poppe style transfer coefficients. These coefficients are defined through empirical correlations which capture the functional dependence of the system. The model has the capability to represent non-uniformities in fill layout and water distribution, which traditional one-dimensional models are unable to resolve. The results show a largely uniform velocity profile across the tower radius with the greatest non-uniformity occurring at the outer edge of the tower. The water outlet temperature was found to vary by 6 K (~40%) between the tower centre and exterior under reference tower conditions. This is largely due to the rise in air temperature and humidity through the rain zone. The considerable non-uniformity of heat transfer across the tower is shown to be tied to the performance of the rain zone. The effect of tower inlet height on radial non-uniformity is surprisingly small but the model is very sensitive to changes in water flow rate. At small fill depths the water temperatures entering the rain zone tend to be higher, which in turn slightly increases the heat transfer rate here and the over-all non-uniformity in the tower.

08/02885 Numerical simulation of shower cooling tower based on artificial neural network

Qi, X. *et al. Energy Conversion and Management*, 2008, 49, (4), 724–732.

This study was prompted by the need to design towers for applications in which, due to salt deposition on the packing and subsequent blockage, the use of tower packing is not practical. The cooling tower analysed in this study is void of fill, named shower cooling tower (SCT). However, the present study focuses mostly on experimental investigation of the SCT, and no systematic numerical method is available. In this paper, the authors first developed a one dimensional model and analysed the heat and mass transfer processes of the SCT; then the concept of artificial neural network (ANN) was used to propose a computer design tool that can help the designer evaluate the outlet water temperature from a given set of experimentally obtained data. For comparison purposes and accurate evaluation of the predictions, part of the experimental data was used to train the neural network and the remainder to test the model. The results predicted by the ANN model were compared with those of the standard model and the experimental data. The ANN model predicted the outlet water temperature with a MAE (mean absolute error) of 1.31%, whereas the standard one dimensional model showed a MAE of 9.42%.

08/02886 Numerical study on temperature stratification in a room with underfloor air distribution system

Kong, Q. and Yu, B. *Energy and Buildings*, 2008, 40, (4), 495–502.

In this study, numerical prediction using computational fluid dynamics (CFD) was utilized to investigate air temperature stratification in a room with an underfloor air distribution (UFAD) system. The numerical modelling using CFD computation was validated with physical test in a full size experimental room with an UFAD system. The different supply air conditions and heat loads were discussed. The results show that the effect of three parameters, heat load, supply volume flux and supply air velocity, on room air temperature would be expressed by the length scale of the floor supply jet. When the length scale increased from 0.8 to 1.56 m, the ratio of vertical temperature difference between 2.5 and 0.1 m at the occupied zone to the difference between return and supply air temperature decreased from 0.62 to 0.25. When there was only one local heat source in the room, there was a thermal stratified interface at the occupied zone. The interface height was about 1.42 times the length scale. The results may suggest ways to optimize UFAD design and operation.

08/02887 Optimizing performance of the lightshelf by modifying ceiling geometry in highly luminous climates

Freewan, A. A. *et al. Solar Energy*, 2008, 82, (4), 343–353.

The impact of ceiling geometries on the performance of lightshelves was investigated using physical model experiments and radiance simulations. Illuminance level and distribution uniformity were assessed for a working plane in a large space located in sub-tropical climate regions where innovative systems for daylighting and shading are required. It was found that the performance of the lightshelf can be improved by changing the ceiling geometry; the illuminance level increased in the rear of the room and decreased in the front near the window compared to rooms having conventional horizontal ceilings. Moreover, greater uniformity was achieved throughout the room as a result of reducing the difference in the illuminance level between the front and rear of the room. Radiance simulation results were found to be in good agreement with physical model data obtained under a clear sky and high solar radiation. The best ceiling shape was found to be one that is curved in the front and rear of the room.

08/02888 Physical and electrochemical properties of spherical $Li_{1+x}(Ni_{1/3}Co_{1/3}Mn_{1/3})_{1-x}O_2$ cathode materials

Park, S.-H. *et al. Journal of Power Sources*, 2008, 177, (1), 177–183.

A $(Ni_{1/3}Co_{1/3}Mn_{1/3})CO_3$ precursor with an uniform, spherical morphology was prepared by coprecipitation using a continuously stirred tank reactor method. The as-prepared spherical $(Ni_{1/3}Co_{1/3}Mn_{1/3})CO_3$ precursor served to produce dense, spherical $Li_{1+x}(Ni_{1/3}Co_{1/3}Mn_{1/3})_{1-x}O_2$ ($0 \leq x \leq 0.15$) cathode materials. These Li-rich cathodes were also prepared by a second synthesis route that involved the use of an M_3O_4 ($M = Ni_{1/3}Co_{1/3}Mn_{1/3}$) spinel compound, itself obtained from the carbonate $(Ni_{1/3}Co_{1/3}Mn_{1/3})CO_3$ precursor. In both cases, the final $Li_{1+}x(Ni_{1/3}Co_{1/3}Mn_{1/3})_{1-x}O_2$ products were highly uniform, having a narrow particle size distribution (10-μm average particle size) as a result of the homogeneity and spherical morphology of the starting mixed-metal carbonate precursor. The rate capability of the $Li_{1+x}(Ni_{1/3}Co_{1/3}Mn_{1/3})_{1-x}O_2$ electrode materials, which was significantly improved with increased lithium content, was found to be better in the case of the denser materials made from the spinel precursor compound. This result suggests that spherical morphology, high density, and increased lithium content were key factors in enabling the high rate capabilities, and hence the power performances, of the Li-rich $Li_{1+x}(Ni_{1/3}Co_{1/3}Mn_{1/3})_{1-x}O_2$ cathodes.

08/02889 Pulsating flow of a hydromagnetic fluid between permeable beds

Malathy, T. and Srinivas, S. *International Communications in Heat and Mass Transfer*, 2008, 35, (5), 681–688.

An investigation is made on the pulsating flow of a hydromagnetic fluid between two permeable beds. The fluid is injected in to the channel from the lower permeable bed with a velocity and is sucked out in to the upper permeable bed with the same velocity with subjection to an imposition of a uniform magnetic field in a direction normal to the flow. The flow between the permeable beds is governed by Navier–Stokes equations and the flow through the permeable beds is governed by Darcy's Law. Analytical expressions for the velocity field and volume flux are obtained. The effects of magnetic field on the velocity fields are calculated numerically for different values of the parameter. The numerical results obtained are presented graphically. It is interesting to note that the velocity can attain its maximum even at the lower permeable bed in the case of some specific choice of parameters. When the Hartmann number M tends to zero, the results agree with those of earlier studies.

08/02890 Recognition of power quality events by using multiwavelet-based neural networks

Kaewarsa, S. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 254–260.

Recognition of power quality events by analysing the voltage and current waveform disturbances is a very important task for the power system monitoring. This paper presents a novel approach for the recognition of power quality disturbances using multiwavelet transform and neural networks. The proposed method employs the multiwavelet transform using multiresolution signal decomposition techniques working together with multiple neural networks using a learning vector quantization network as a powerful classifier. Various transient events are tested, such as voltage sag, swell, interruption, notching, impulsive transient, and harmonic distortion show that the classifier can detect and classify different power quality signal types efficiency.

08/02891 REST2: high-performance solar radiation model for cloudless-sky irradiance, illuminance, and photosynthetically active radiation – validation with a benchmark dataset

Gueymard, G. A. *et al. Solar Energy*, 2008, 82, (3), 272–285.

REST2, a high-performance model to predict cloudless-sky broadband irradiance, illuminance and photosynthetically active radiation (PAR) from atmospheric data, is presented. Its derivation uses the same two-band scheme as in the previous CPCR2 model, but with numerous improvements. Great attention is devoted to precisely account for the effect of aerosols, in particular. Detailed research-class measurements from Billings, Oklahoma are used to assess the performance of the model for the prediction of direct, diffuse and global broadband irradiance. These measurements were made in May 2003 during a sophisticated radiative closure experiment, which involved the best radiometric instrumentation currently available and many ancillary instruments. As a whole, these exceptional measurements constitute the only known modern benchmark dataset made specifically to test the intrinsic performance of radiation models. Using this dataset as reference, it is shown that REST2 performs better than CPCR2 for irradiance, illuminance or PAR predictions. The availability of the turbidity data required by REST2 or other similar models is also discussed, as well as the effect that turbidity has on each component of broadband irradiance, PAR irradiance and illuminance, and on the diffuse/global PAR ratio.

08/02892 Sensitivity analysis of a light gas oil deep hydrodesulfurization process via catalytic distillation

Rosales-Quintero, A. *et al. Catalysis Today*, 2008, 130, (2–4), 509–518.

In this work, a sensitivity analysis of a light gas oil deep hydrodesulfurization catalytic distillation column is presented. The aim is to evaluate the effects of various parameters and operating conditions on the organic sulfur compound elimination by using a realistic light gas oil fraction. The hydrocarbons are modelled using pseudocompounds, while the organic sulfur compounds are modelled using model compounds, i.e. dibenzothiophene (DBT) and 4,6-dimethyl dibenzothiophene (4,6-DMDBT). These are among the most refractive sulfur compounds present in the oil fractions. A sensitivity analysis is discussed for the reflux ratio, bottom flow rate, condenser temperature, hydrogen and gas oil feed stages, catalyst loading, the reactive, stripping, and rectifying stages, feed disturbances, and multiple feeds. The results give insight into the qualitative effect of some of the operating variables and disturbances on organic sulfur elimination. In addition, they show that special attention must be given to the bottom flow rate and LGO feed rate control.

08/02893 Software for fast cameras and image handling on MAST

Shibaev, S. and MAST, *Fusion Engineering and Design*, 2008, 83, (4), 667–671.

The rapid progress in fast imaging gives new opportunities for fusion research. The data obtained by fast cameras play an important and ever-increasing role in analysis and understanding of plasma phenomena. The fast cameras produce a huge amount of data which creates considerable problems for acquisition, analysis, and storage. A number of fast cameras are used on the mega-amp spherical tokamak (MAST). They cover several spectral ranges: broadband visible, infra-red and narrow band filtered for spectroscopic studies. These cameras are controlled by programs developed in-house. The programs provide full camera configuration and image acquisition in the MAST shot cycle. Despite the great variety of image sources, all images should be stored in a single format. This simplifies development of data handling tools and hence the data analysis. A universal file format has been developed for MAST images which supports storage in both raw and compressed forms, using either lossless or lossy compression. A number of access and conversion routines have been developed for all languages used on MAST. Two movie-style display tools have been developed – Windows native and Qt based for Linux. The camera control programs run as autonomous data acquisition units with full camera configuration set and stored locally. This allows easy porting of the code to other data acquisition systems. The software developed for MAST fast cameras has been adapted for several other tokamaks where it is in regular use.

08/02894 Solubility of Dagang vacuum residue and molecular composition of the soluble fractions in different solvents

Han, L. *et al. Fuel*, 2008, 87, (2), 260–263.

Dagang vacuum residue (DVR) was ultrasonically extracted with 15 organic solvents, respectively, and the soluble fractions (SFs) were analysed with GC/MS. The results show that DVR tends to dissolve in non-polar solvent and that most of GC/MS-detectable components in the SFs are saturated hydrocarbons.

08/02895 Thermal performance of a pipe in pipe heat exchanger with sinusoidal inner pipe

Moawed, M. A. *et al. Energy Conversion and Management*, 2008, 49, (4), 678–686.

Heat and fluid flow characteristics for sinusoidal smooth pipes with different wavelength and amplitude have been investigated experimentally. The effects of the dimensionless wavelength (a/d_i) and the amplitude (b/d_i) on the thermal performance of a sinusoidal pipe inside a straight pipe heat exchanger are investigated. The experiments employed one straight smooth pipe, five sinusoidal smooth pipes at different a/d_i and three sinusoidal smooth pipes at different b/d_i. The Reynolds number ranged from 8.8×10^3 to 2.8×10^4, and the Prandtl number ranged from 4.53 to 5.85. The range of the dimensionless wavelength (b/d_i) is from 18.52 to 55.55, and the dimensionless amplitude (a/d_i) range is from 4 to 13.6. The results showed that the heat transfers in sinusoidal pipes are increased in all cases of a/d_i and b/d_i above those of the straight pipe. Also, the friction factor (f) in the sinusoidal pipes is increased in all cases of a/d_i and b/d_i above that of the straight pipe. The dimensionless exergy loss (e) decreases with the increase of b/d_i, but in the case of a/d_i, the maximum of e is attained at $a/d_i = 6.22$ and the minimum is attained at $a/d_i = 13.6$. Correlations of Nu and f as a function of Re, b/d_i and a/d_i are presented. Also, a correlation of e as a function of Re, b/d_i and a/d_i is given.

08/02896 Transient behavior of water generation in a proton exchange membrane fuel cell

Hao, L. *et al. Journal of Power Sources*, 2008, 177, (2), 404–411.

The effect of water generation on the performance of proton exchange membrane fuel cell (PEMFC) was investigated by using a periodical linear sweep method. Three different kinds of *I–V* curves were obtained, which reflected different amount of water uptake in the fuel cell. The maximum water uptake that could avoid flooding in the fuel cell and the hysteresis of water diffusion were also discussed. Quantitative analysis of water uptake and water transport phenomena in this study were conducted both experimentally and theoretically. Results showed that the water uptake capacity for the fuel cell under no severe flooding was 27.837 mg cm^{-2}. The transient response of the internal resistance indicated that the high frequency resistance (HFR) lagged the current with a value of about 20 s. The effect of purging operation on the internal resistance of the fuel cell was also explored. Experimental data showed that the cell experienced a continuous 8-min purging process can maintain at a relatively steady and dry state.

08/02897 Using measurements in urban areas to estimate turbulent velocities for modeling dispersion

Venkatram, A. and Princevac, M. *Atmospheric Environment*, 2008, 42, (16), 3833–3841.

This study extends a study in which mean winds and temperatures measured at one or two levels on towers located in urban areas were fitted to Monin–Obukhov similarity equations to obtain estimates of micrometeorological variables required in modelling dispersion in the stable boundary layer. This study shows that such methods are also useful in unstable conditions: measurements of the mean wind speed and the standard deviation of temperature fluctuations, σ_T, at one level on a tower yield estimates of surface heat flux, surface friction velocity, and standard deviations of turbulent velocities that are within a factor of two of values observed at two urban sites over 80% of the time.

08/02898 View factor calculation in the 2-D geometries using the collapsed dimension method

Mishra, S. C. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (5), 630–636.

Usage of the collapsed dimension method (CDM) applied so far in solving radiative transport problems with participating media has been extended for the determination of view factors of the two-dimensional geometries. Unlike its application in the participating media, in view factor calculations, the CDM does not require tracing of rays, and thus its expressions are exact. To test the applicability of the CDM for the calculation of view factors, two geometries were considered. The CDM results were found to match precisely with the exact results. If in the CDM, the view factor expressions are not considered exact, the ray tracing becomes mandatory and, in this method too like the discrete ordinate method, the discrete transfer method and the finite volume method, ray effect manifests. For this situation, for a given number of control surfaces, effects of number rays were studied and trends were found similar to those found in other methods.

Fuel cell technology

08/02899 A micro-solid oxide fuel cell system as battery replacement

Bieberle-Hütter, A. *et al. Journal of Power Sources*, 2008, 177, (1), 123–130.

The concept and the design of a micro-solid oxide fuel cell system is described and discussed. The system in this study is called the ONEBAT system and consists of the fuel cell PEN (positive electrode–electrolyte–negative electrode) element, a gas processing unit, and a thermal system. PEN elements of free-standing multi-layer membranes are fabricated on Foturan® and on Si substrates using thin film deposition and microfabrication techniques. Open circuit voltages of up to 1.06 V and power of 150 mW cm^{-2} are achieved at 550 °C. The membranes are stable up to 600 °C. The gas processing unit allows butane conversion of 95% and hydrogen selectivity of 83% at 550 °C in the reformer and efficient after-burning of hydrogen, carbon monoxide, and lower hydrocarbons in the post-combustor. Thermal system simulations prove that a large thermal gradient of more than 500 °C between the hot module and its exterior are feasible. The correlation between electrical power output – system size and thermal conductivity – heat-transfer coefficient of the thermal insulation material are shown. The system design studies show that the single sub-systems can be integrated into a complete system and that the requirements for portable electronic devices can be achieved with a base unit of 2.5 W and a modular approach.

08/02900 A PEMFC and H_2 membrane purification integrated plant

Brunetti, A. *et al. Chemical Engineering and Processing: Process Intensification*, 2008, 47, (7), 1081–1089.

In this work an integrated system composed of a Pd–Ag membrane module and a polymeric electrolyte fuel cell (PEMFC) was studied. The Pd–Ag membrane module, allowing a pure hydrogen permeate stream to be fed directly to the PEMFC, was used as an H_2 purification step with a mixture containing also CO and CO_2. The CO poisoning effect on the Pd–Ag membrane and its consequences on the hydrogen permeation were analysed in a temperature range 300–450 °C in terms of permeance reduction conditioning also the H_2 recovery index. A comparison between the experimental data obtained feeding the fuel cell with pure H_2 from a cylinder and from the purification step was also performed in order to evaluate the PEMFC performance stability. After the experimental study of each single step, particular attention was devoted to the analysis of the integrated system Pd–Ag membrane purification step – PEMFC, focusing on the influence of the Pd–Ag membrane module operating conditions on the electrical performance of the PEMFC. The PEMFC internal crossover was also considered and its effects on the electrical performance were taken into account by means of a PEMFC actual efficiency. Furthermore, integrated membrane plant chemical efficiency was defined considering the H_2 converted into electricity with respect to the total amount of H_2 contained in the mixture. The integrated Pd–Ag membrane purification with PEMFC shows very good results: the hydrogen is well purified and the PEMFC performance is very high near the nominal value.

08/02901 Catalytic hydrogen/oxygen reaction assisted the proton exchange membrane fuel cell (PEMFC) startup at subzero temperature

Sun, S. *et al. Journal of Power Sources*, 2008, 177, (1), 137–141.

Fuel cells for automobile application need to operate in a wide temperature range including freezing temperature. However, the rapid startup of a proton exchange membrane fuel cell (PEMFC) at subfreezing temperature, e.g. $-20\,^{\circ}\mathrm{C}$, is very difficult. A cold-start procedure was developed, which made hydrogen and oxygen react to heat the fuel cell considering that the FC flow channel was the characteristic of microchannel reactor. The effect of hydrogen and oxygen reaction on fuel cell performance at ambient temperature was also investigated. The electrochemical characterizations such as *I–V* plot and cyclic voltammetry (CV) were performed. The heat generated rate for either the single cell or the stack was calculated. The results showed that the heat generated rate was proportional to the gas flow rate when H_2 concentration and the active area were constant. The fuel cell temperature rose rapidly and steadily by controlling gas flow rate.

08/02902 Comparison of heat and mass transfer between planar and MOLB-type SOFCs

Yang, Y. *et al. Journal of Power Sources*, 2008, 177, (2), 426–433.

A numerical simulation tool for calculating the planar and mono-block layer built (MOLB) type solid oxide fuel cells (SOFC) is described. The tool combines the commercial computational fluid dynamics simulation code with an electrochemical calculation subroutine. Its function is to simulate the heat and mass transfer and to predict the temperature distribution and mass fraction of gaseous species in the SOFC system. The three-dimensional geometry model of SOFC was designed to simulate a co-flow case and counter-flow case. The finite volume method was employed to calculate the conservation equations of mass, momentum and energy. Moreover, the influences of working conditions on the performances of planar and MOLB-type SOFCs were also discussed and compared, such as the delivery rate of gas and the components of fuel gas. Simulation results show that the MOLB-type SOFC has higher fuel utilization than the planar SOFC. For the co-flow case, average temperatures of PEN (positive electrode–electrolyte–negative electrode) in both types of SOFCs rise with the increase in delivery rate and mass fraction of hydrogen. In particular, the temperature of planar SOFC is more sensitive to the working conditions. In order to decrease the average temperatures in SOFC, it is effective to increase the delivery rate of air.

08/02903 Effect of PTFE content in microporous layer on water management in PEM fuel cells

Park, S. *et al. Journal of Power Sources*, 2008, 177, (2), 457–463.

The effect of hydrophobic agent [polytetrafluoroethylene (PTFE)] concentration in the microporous layer on the proton exchange membrane (PEM) fuel cell performance was investigated using mercury porosimetry, water permeation experiment, and electrochemical polarization technique. The mercury porosimetry and water permeation experiments indicated that PTFE increases the resistance of the water flow through the GDL due to a decrease of the MPL porosity and an increase of the volume fraction of hydrophobic pores. When air was used as an oxidant, a maximum fuel cell performance was obtained for a PTFE loading of 20 wt.%. The experimental polarization curves were quantitatively analysed to determine the polarization resistances resulting from different physical and electrochemical processes in the PEM fuel cell. The polarization analysis indicated that the optimized PTFE content results in an effective water management (i.e. a balancing of water saturations in the catalyst layer and the gas diffusion layer), thereby improving the oxygen diffusion kinetics in the membrane-electrode assembly.

08/02904 Experimental and analytical investigation of molten carbonate fuel cell stack

Yu, L. *et al. Energy Conversion and Management*, 2008, 49, (4), 873–879.

A high temperature molten carbonate fuel cell (MCFC) stack has been studied experimentally and computationally. A kilowatt scale MCFC stack test station was designed and installed, and experimental investigations of the stack performance were conducted. A three-dimensional, variational parameter numerical model was developed and used to simulate the central fuel cell in the stack. Heat generation, mass transfer between anode and cathode and electrochemical characteristics of the fuel cell were considered in developing the model. The distributions of temperature on the cathode/current collector interface, current density, power density, water vapour concentration in the anode flow channel and velocity for the fuel cell were simulated by solving the model using the computational fluid dynamics technique. Simulation results show that the temperature, current and power densities reach their maximal values at the channel outlet. The comparison of the modelling results and experimental data shows good agreement.

08/02905 Fabrication and testing of coplanar single-chamber micro solid oxide fuel cells with geometrically complex electrodes

Kuhn, M. *et al. Journal of Power Sources*, 2008, 177, (1), 148–153.

Coplanar single-chamber micro solid oxide fuel cells (SC-μSOFCs) with curvilinear microelectrode configurations of arbitrarily complex two-dimensional geometry were fabricated by a direct-write microfabrication technique using conventional fuel cell materials. The electrochemical performance of two SC-μSOFCs with different electrode shapes, but comparable electrode and inter-electrode dimensions, was characterized in a methane–air mixture at $700\,^{\circ}\mathrm{C}$. Both cells exhibited stable open circuit voltage and peak power density of $0.9\,\mathrm{V}$ and $2.3\,\mathrm{mW\,cm^{-2}}$, respectively, indicating that electrode shape did not have a significant influence on the performance of these fuel cells.

08/02906 Fuel cell operation under degraded working modes and study of diode by-pass circuit dedicated to multi-stack association

Candusso, D. *et al. Energy Conversion and Management*, 2008, 49, (4), 880–895.

To make fuel cells commercially viable in the transportation sector, it now becomes crucial to develop some technical concepts that allow continuation of the operation of the multi-stack generator even if one stack fails. This paper presents some studies related to the electrical behaviour of a polymer electrolyte fuel cell operated under fault condition and equipped with an anti-parallel diode used as a by-pass circuit. Some experimental results are obtained using a two cell stack placed in a set-up that reproduces the coupling in series of two fuel cell stacks. These results allow evaluation of the by-pass diode solutions in the case of fuel cell specific degraded working modes, such as the break of the gas reactant feed. The impacts of the starvation phenomenon on the stack performances are analysed and commented upon from the characterization data obtained, in particular, by electrochemical impedance spectroscopy. Some extrapolation and extension of the first experimental investigations are done with the aim of preparing the next association of higher power stacks operated with their reverse diodes. The proposed experimental and modelling works show that the value of the stack impedance will have a key role in triggering the diode conduction.

08/02907 Modeling and simulation of solid oxide fuel cell based on the volume–resistance characteristic modeling technique

Wang, L. *et al. Journal of Power Sources*, 2008, 177, (2), 579–589.

Solid oxide fuel cell (SOFC) is a complicated system with heat and mass transfer as well as electrochemical reactions. The real-time dynamic simulation of SOFC is still a challenge up to now. This paper develops a one-dimensional mathematical model for direct internal reforming solid oxide fuel cell (DIR-SOFC). The volume–resistance (*V–R*) characteristic modelling technique is introduced into the modelling of the SOFC system. Based on the *V–R* modelling technique and the modular modelling idea, ordinary differential equations meeting the quick simulation are obtained from partial differential equations. This model takes into account the variation of local gas properties. It can not only reflect the distributed parameter characteristics of SOFC, but also meet the requirement of the real-time dynamic simulation. The results indicate that the *V–R* characteristic modelling technique is valuable and viable in the SOFC system, and the model can be used in the quick dynamic and real-time simulation.

08/02908 Modelling of fuel cells using multi-domain VHDL-AMS language

Blunier, B. and Miraoui, A. *Journal of Power Sources*, 2008, 177, (2), 434–450.

This study presents an IEEE standard very high-speed integrated circuit hardware description language-analogue and mixed-signal extension (VHDL-AMS) modelling of a complex multi-domain energy conversion system: a fuel cell stack. A comparative study between the different modelling approaches (bond graphs, electrical equivalent circuits) is given to show the great advantages of the VHDL-AMS language in the design process of fuel cell systems. The modelling approach allows the design team to split the work into several parts (concurrent engineering) and validate each part independently. The fuel cell stack model fits the experimental results. It is able to predict the voltage and the power of the fuel cell with a good accuracy taking into account the water content of the membrane. This last point is really important to design the air supply system (compressor and humidifier) and its associated control.

08/02909 Multivariable robust control of a proton exchange membrane fuel cell system

Wang, F.-C. *et al. Journal of Power Sources*, 2008, 177, (2), 393–403.

This paper applies multivariable robust control strategies to a proton exchange membrane fuel cell (PEMFC) system. From the system point of view, a PEMFC can be modelled as a two-input–two-output system, where the inputs are air and hydrogen flow rates and the outputs are cell voltage and current. By fixing the output resistance, the aim was to control the cell voltage output by regulating the air and hydrogen flow rates. Due to the non-linear characteristics of this system, multivariable robust controllers were designed to provide robust performance and to reduce the hydrogen consumption of this system. The study was carried out in three parts. Firstly, the PEMFC system was modelled as multivariable transfer function matrices using identification techniques, with the unmodelled dynamics treated as system uncertainties and disturbances. Secondly, robust control algorithms were utilized to design multivariable H_∞ controllers to deal with system uncertainty and performance requirements. Finally, the designed robust controllers were implemented to control the air and hydrogen flow rates. From the experimental results, multivariable robust control is shown to provide steady output responses and significantly reduce hydrogen consumption.

08/02910 Solid-oxide fuel cell operated on in situ catalytic decomposition products of liquid hydrazine

Gu, H. *et al. Journal of Power Sources*, 2008, 177, (2), 323–329.

Hydrazine was examined as a fuel for a solid-oxide fuel cell (SOFC) that employed a typical nickel-based anode. An *in situ* catalytic decomposition of hydrazine at liquid state under room temperature and ambient pressure before introducing to the fuel cell was developed by applying a $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF) oxide catalyst. Catalytic testing demonstrated that liquid N_2H_4 can be decomposed to gaseous NH_3 and H_2 at a favourable rate and at a temperature as low as 20 °C and H_2 selectivity reaching values as high as 10% at 60 °C. Comparable fuel cell performance was observed using either the *in situ* decomposition products of hydrazine or pure hydrogen as fuel. A peak power density of $\sim$850 mW cm^{-2} at 900 °C was obtained with a typical fuel cell composed of scandia-stabilized zirconia and $La_{0.8}Sr_{0.2}MnO_3$ cathode. The high energy and power density, easy storage and simplicity in fuel delivery make it highly attractive for portable applications.

08/02911 The electrical resistance of flexible graphite as flowfield plate in proton exchange membrane fuel cells

Fu, Y. *et al. Carbon*, 2008, 46, (1), 19–23.

Flexible graphite can be stamped into gas channels for proton exchange membrane fuel cells attributing to its good conductivity, corrosion resistance and flexibility. However, the electrical resistance of the bipolar plate consisting of a coated metal foil and the stamped flexible graphite flowfield plate should be investigated, for the internal resistance would affect the output power of the fuel cell greatly. The influences of various parameters, such as compacting pressure, temperature, effective area of the coating and the water content of the flexible graphite on the electrical resistance were studied. The electrical resistance decreases with the increment of compacting pressure exponentially. The temperature and the effective area of metal foil coating both have linear relations with the electrical resistance. And the water content of the flexible graphite has a very complex relation with the electrical resistance; it is the most important influencing factor. At last, an empirical equation for the electrical resistance, giving a good fit to the test data, was determined.

08/02912 Two-phase flow modeling of liquid-feed direct methanol fuel cell

Yan, T. Z. and Jen, T.-C. *International Journal of Heat and Mass Transfer*, 2008, 51, (5–6), 1192–1204.

A two-phase flow model was developed for liquid-feed methanol fuel cells (DMFC) to evaluate the effects of various operating parameters on the DMFC performance. In this study, a general homogenous two-dimensional model is described in details for both porous layers and fluid channels. This two-dimensional general model accounts for fluid flow, electrochemical kinetics, current density distribution, hydrodynamics, multi-component transport, and methanol crossover. It starts from basic transport equations including mass conservation, momentum transport, energy balance, and species concentration conservation in different elements of the fuel cell sandwich, as well as the equations for the phase potential in the membrane and the catalyst layers. These governing equations are coupled with chemical reaction kinetics by introducing various source terms. It is found that all these equations are in a very similar form except the source terms. Based on this observation, all the governing equations can be solved using the same numerical formulation in the single domain without prescribing the boundary conditions at the various interfaces between the different elements of the fuel cell. The numerical simulation results, such as velocity field, local current density distribution, and species concentration variation along the flow channel, under various operation conditions are computed. The performance of the DMFC affected by various parameters such as temperature, pressure, and methanol concentration is investigated in this paper. The numerical results are further validated with available experimental data from the published literatures.

15 ENVIRONMENT

Pollution, health protection, applications

08/02913 A computational method to assess the impact of urban climate on buildings using modeled climatic data

Oxizidis, S. *et al. Energy and Buildings*, 2008, 40, (3), 215–223.

In the last decade a lot of research effort has been spent on identifying the effect of the urban climate on the energy performance of buildings and heating, ventilation and air conditioning (HVAC) systems. In this paper a methodology is proposed to assess that effect by the exclusive use of modelled data. Particularly, by using a downscaling modelling procedure a process for the generation of weather files for energy calculations is achieved. From a non-hydrostatic weather model the urban climate of the city of Lisbon is simulated and via a weather generator climatic data files for the buildings' simulation software are derived. The results on the energy behaviour of a reference test cell for different sites inside the city of Lisbon are presented.

08/02914 Analysis of domestic hot water energy consumption in large buildings under standard conditions in Senegal

Ndoye, B. and Sarr, M. *Building and Environment*, 2008, 43, (7), 1216–1224.

This paper presents an investigation of the energy consumption due to domestic hot water (DHW) production in large buildings. Three types of reference buildings were studied: one office, one residence and a three-star hotel located in Senegal. The DOE2.1E (the building energy program of the Department of Energy Version 2.1E) has been used. One of its main advantage is that it allows to take into account both energy end use categories and a great number of parameters of the building energy performance. Four climatic regions have been identified and their equivalent 'standard' conditions are all defined. Those conditions are the same as the current design and operating conditions of each type of building. The DHW energy consumption is calculated and compared with the total energy generated by all end uses (lighting, cooling/ventilation, DHW, and other equipment). Before wide and systematic simulations of the three buildings energy performance were carried out, special attention was paid to check and validate the DHW part of the DOE2.1E model. There was an agreement between the recorded monthly DHW energy load on the one hand, and on the other the computed results. The authors end up finding results that could open new perspectives for building a strategic methodology to provide guidelines for DHW energy saving measures in large buildings in West Africa. Furthermore, it is expected that energy researchers concerned about energy and environmental efficiency would consider this study for promoting CO_2 emission reduction in relation with DHW production in large buildings.

08/02915 Atmospheric monitoring and verification technologies for CO_2 geosequestration

Leuning, R. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (3), 401–414.

The paper describes various techniques for measuring emissions to the atmosphere from geologically stored carbon dioxide, from point, line and area sources at scales of metres to several kilometres. Flux chambers are suitable for measuring small leakage rates from sources at known locations but many samples are required because of large spatial heterogeneity in the fluxes. Micrometeorological eddy covariance, relaxed eddy accumulation and flux-gradient techniques are suitable for measuring leakage from large area sources, while integrated horizontal mass balance, tracer methods and plume dispersion approaches are applicable for line and point sources. Distinguishing between leakage signals and natural fluctuations in CO_2 concentrations due to biogenic sources pose significant challenges and the use of naturally occurring tracers such as CO_2 isotopologues or introduced tracers such as SF_6 added to the sequestered CO_2 will assist with this problem. Forward Lagrangian dispersion calculations showed that CO_2 concentrations 0–80 m downwind of a point source would be readily detectable above all natural variations for point sources $>0.3\,g\,CO_2\,s^{-1}$ (about 10 tonnes of CO_2 per year). The inverse problem involves solving for the unknown emission rate from measured wind fields and down wind concentration perturbations. An optimum monitoring strategy for inverse analysis will require continuous measurements of CO_2 and tracer compounds upwind and downwind of the possible leak location, coupled with transport modelling to determine leakage fluxes, and to differentiate them from other sources. Computations using The air pollution model (TAPM) showed that expected perturbations in CO_2 concentrations at distances of several hundred metres from a leak of $32\,g\,CO_2\,s^{-1}$ (about 1000 tonnes CO_2 per year, or about 0.01% per year of a typical amount to be stored) will be detectable, but this anomaly will be very small compared to natural variations, thereby complicating the inverse analysis. While the techniques canvassed here have proven successful for measuring fluxes in other applications, none has yet been demonstrated for geosequestration. The next step is to test them in the field.

08/02916 Comparison of environmental impacts of two residential heating systems

Yang, L. *et al. Building and Environment*, 2008, 43, (6), 1072–1081.

This paper presents a comparison of environmental impacts of two residential heating systems, a hot water heating (HWH) system with mechanical ventilation and a forced air heating (FAH) system. These two systems are designed for a house recently built near Montreal, Canada. The comparison is made with respect to the life-cycle energy use, the life-cycle greenhouse gas (GHG) emissions, the expanded cumulative exergy consumption (ECExC), the energy and exergy efficiencies, and the life-cycle cost. The results indicate that the heating systems cause marginal impacts compared with the entire house in the pre-operating phase. In the operating phase, on the other hand, they cause significant environmental impacts. The HWH systems with a heat recovery ventilator (HRV) using either electricity or natural gas have the lowest life-cycle energy use and lowest ECExC. The HWH and FAH systems using electricity as energy source have the lowest GHG emissions. Finally, the FAH systems have, on the average, a lower life-cycle cost than the HWH systems.

08/02917 CO_2 transportation for carbon capture and storage: sublimation of carbon dioxide from a dry ice bank

Mazzoldi, A. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (2), 210–218.

Climate change is being caused by greenhouse gases such as carbon dioxide (CO_2). Carbon capture and storage (CCS) is of interest to the scientific community as one way of achieving significant global reductions of atmospheric CO_2 emissions in the medium term. CO_2 would be captured from large stationary sources such as power plants and transported via pipelines under high pressure conditions to underground storage. If a downward leakage from a surface transportation system module occurs, the CO_2 would undergo a large temperature reduction and form a bank of ‘dry ice’ on the ground surface; the sublimation of the gas from this bank represents an area source term for subsequent atmospheric dispersion, with an emission rate dependent on the energy balance at the bank surface. Gaseous CO_2 is denser than air and tends to remain close to the surface; it is an asphyxiant, a cerebral vasodilator and at high concentrations causes rapid circulatory insufficiency leading to coma and death. Hence a subliming bank of dry ice represents safety hazard. A model is presented for evaluating the energy balance and sublimation rate at the surface of a solid frozen CO_2 bank under different environmental conditions. The results suggest that subliming gas behaves as a proper dense gas (i.e. it remains close to the ground surface) only for low ambient wind speeds.

08/02918 Design of intelligent comfort control system with human learning and minimum power control strategies

Liang, J. and Du, R. *Energy Conversion and Management*, 2008, 49, (4), 517–528.

This paper presents the design of an intelligent comfort control system by combining the human learning and minimum power control strategies for the heating, ventilating and air conditioning (HVAC) system. In the system, the predicted mean vote (PMV) is adopted as the control objective to improve indoor comfort level by considering six comfort related variables, whilst a direct neural network controller is designed to overcome the non-linear feature of the PMV calculation for better performance. To achieve the highest comfort level for the specific user, a human learning strategy is designed to tune the user’s comfort zone, and then, a VAV and minimum power control strategy is proposed to minimize the energy consumption further. In order to validate the system design, a series of computer simulations are performed based on a derived HVAC and thermal space model. The simulation results confirm the design of the intelligent comfort control system. In comparison to the conventional temperature controller, this system can provide a higher comfort level and better system performance, so it has great potential for HVAC applications in the future.

08/02919 Developing and testing an operational framework for assessing quality of life

Fahy, F. and Cinnéide, M. Ó *Environmental Impact Assessment Review*, 2008, 28, (6), 366–379.

Difficulties with operationalising the concept of sustainable development have generated much debate, and have stimulated a good deal of research on the challenging task of assessing progress towards that goal. This paper focuses on quality of life, as one discourse in the sustainable development literature, and reports on the development and testing of an operational framework for the assessment of quality of life in an urban setting. Core principles of sustainable development are translated into a set of operational criteria for investigating quality of life. The process of formulating these criteria and the manner in which they may be linked to policy and practice are outlined. The application of the framework is demonstrated by reference to the experience of implementing it in an urban centre in Ireland.

08/02920 Effects of acid mine drainage on dissolved inorganic carbon and stable carbon isotopes in receiving streams

Fonyuy, E. W. and Atekwana, E. A. *Applied Geochemistry*, 2008, 23, (4), 743–764.

Dissolved inorganic carbon (DIC) constitutes a significant fraction of a stream’s carbon budget, yet the role of acid mine drainage (AMD) in DIC dynamics in receiving streams remains poorly understood. The objective of this study was to evaluate spatial and temporal effects of AMD and its chemical evolution on DIC and stable isotope ratio of DIC ($\delta^{13}C_{DIC}$) in receiving streams. The authors examined spatial and seasonal variations in physical and chemical parameters, DIC, and $\delta^{13}C_{DIC}$ in a stream receiving AMD. In addition, different proportions of AMD and tap water were mixed in a laboratory experiment to investigate AMD dilution and variable bicarbonate concentrations to simulate downstream and seasonal hydrologic conditions in the stream. Field and laboratory samples showed variable pH, overall decreases in Fe^{2+}, alkalinity, and DIC, and variable increase in $\delta^{13}C_{DIC}$. The authors attribute the decrease in alkalinity, DIC loss, and enrichment of ^{13}C of DIC in stream water to protons produced from oxidation of Fe^{2+} followed by Fe^{3+} hydrolysis and precipitation of $Fe(OH)_{3(s)}$. The extent of DIC decrease and ^{13}C enrichment of DIC was related to the amount of HCO_3^- dehydrated by protons. The laboratory experiment showed that lower ^{13}C enrichment occurred in unmixed AMD (2.7‰) when the amount of protons produced was in excess of HCO_3^- or in tap water (3.2‰) where no protons were produced from Fe^{3+} hydrolysis for HCO_3^- dehydration. The ^{13}C enrichment increased and was highest for AMD-tap water mixture (8.0‰) where Fe^{2+} was proportional to HCO_3^- concentration. Thus, the variable downstream and seasonal ^{13}C enrichment in stream water was due in part to: (1) variations in the volume of stream water initially mixed with AMD and (2) to HCO_3^- input from groundwater and seepage in the downstream direction. Protons produced during the chemical evolution of AMD caused seasonal losses of 50 to >98% of stream water DIC. This loss of DIC in AMD impacted streams may have implications for CO_2 transfer to the atmosphere and watershed DIC export.

08/02921 Global energy and emissions scenarios for effective climate change mitigation – deterministic and stochastic scenarios with the TIAM model

Syri, S. *et al. International Journal of Greenhouse Gas Control*, 2008, 2, (2), 274–285.

The achievement possibilities of the European Union (EU) 2 °C climate target have been assessed with the ETSAP TIAM global energy systems model. Cost-effective global and regional mitigation scenarios of carbon dioxide, methane, nitrous oxide and F-gases were calculated with alternative assumptions on emissions trading. In the mitigation scenarios, an 85% reduction in CO_2 emissions is needed from the baseline, and very significant changes in the energy system towards emission-free sources take place during this century. The largest new technology groups are carbon-capture and storage (CCS), nuclear power, wind power, advanced bioenergy technologies and energy efficiency measures. CCS technologies contributed a 5.5-Pg CO_2 annual emission reduction by 2050 and 12 Pg CO_2 reduction by 2100. Also large-scale forestation measures were found cost-efficient. Forestation measures reached their maximum impact of 7.7 Pg CO_2 annual emission reduction in 2080. The effects of uncertainties in the climate sensitivity have been analysed with stochastic scenarios.

08/02922 KURT, a small-scale underground research laboratory for the research on a high-level waste disposal

Cho, W.-J. *et al. Annals of Nuclear Energy*, 2008, 35, (1), 132–140.

To obtain information on an underground environment and to investigate the behaviour of repository barriers in an underground environment, a small-scale underground research laboratory named KURT was constructed at the Korea Atomic Energy Research Institute. Geological survey including a seismic refraction survey, an electronic resistivity survey, and a borehole drilling as well as *in situ* and laboratory tests were carried out. Using the geological survey results, the design of KURT and an analysis of its mechanical stability to confirm the validity of the design were performed. The construction of KURT was started in May 2005 and it was successfully completed in July 2006. Also, the operation of KURT was started in November 2006. The research programs in KURT are introduced here.

08/02923 MICS-Asia II: modeling gaseous pollutants and evaluating an advanced modeling system over East Asia

Fu, J. S. *et al. Atmospheric Environment*, 2008, 42, (15), 3571–3583.
An advanced modelling system with a ‘one-atmosphere’ perspective, Models-3/community multi-scale air quality modelling system, driven by MM5/NCEP reanalysis data as the meteorology, and GEOS-Chem outputs as boundary values was applied to simulate the O_3, and other gaseous pollutants (SO_2 and NO_2) evolution among other atmospheric chemicals for July 2001. Comparisons had been made with other models in the MICS-II exercise for the same period. Statistics of both monthly and daily means show that the model skill is very good in reproducing O_3 and SO_2 with small to moderate RMSE. The model species capture the day-to-day and spatial variability of the observations. The same O_3 model concentrations that overpredict most of the EANET observations in the MICS-II study may have under predicted ones from monitoring networks in Beijing area that is not included in this paper. Vertical O_3 profiles at four ozonesonde sites are well predicted in July 2001. In fact, the model is among the best of those MICS-II models within the 2-km surface layer. The meteorology near surface and lower troposphere is well reproduced. Compared to SO_2 and O_3, the NO_2 gas concentrations are simulated less well, but the correlation coefficient is still significant. The choice of reanalysis meteorological fields and different boundary conditions generated by different global models may result in diverse spatial patterns exhibited by MICS-II models and ours. The spatial distributions of O_3 shows a high concentration patch covering Beijing, a moderate to high pattern across Korea and Japan Sea, and a low but extensive pattern enclosing southern China, Taiwan, and East Sea. Extension of the pattern to southern China coincides with the existence of pollution problems in Guangdong and Taiwan, but over-prediction of O_3 over the region deserves further improvement by various factors. One of them can be the grid resolution to resolve the complex orography in or close to the ocean. Another factor can be the refinement of local land use data that changes the micro-meteorology in favour of more air pollution events.

08/02924 Mitigating greenhouse: limited time, limited options

Moriarty, P. and Honnery, D. *Energy Policy*, 2008, 36, (4), 1251–1256.
Most human-caused climate change comes from fossil fuel combustion emissions. To avoid the risk of serious climate change, very recent research suggests that emission reductions will need to be both large and rapidly implemented. It is argued that technical solutions – improving energy efficiency, use of renewable and nuclear energy, and carbon capture and sequestration – can only be of minor importance, mainly given the limited time available to take effective climate action. Only curbing energy use, perhaps through ‘social efficiency’ gains, particularly in the high-energy consumption countries, can provide the rapid emissions reductions needed. The social efficiency approach requires a basic rethinking in how human needs can be satisfied with low environmental impacts. Large cuts in emissions could then occur rapidly, but only if resistance to such changes can be overcome. Particularly in transport, there are also serious potential conflicts between the technical and the social efficiency approaches, requiring a choice to be made.

08/02925 Modeling regulatory policies associated with offshore structure removal requirements in the Gulf of Mexico

Kaiser, M. J. *Energy*, 2008, 33, (7), 1038–1054.
Federal regulations require that a lease in the outer continental shelf of the Gulf of Mexico be cleared of all structures within one year after production on the lease ceases, but in recent years, the Minerals Management Service has begun to encourage operators to remove idle (non-producing) structures on producing leases that are no longer ‘economically viable’. At the end of 2003, there were 2175 producing structures, 898 idle (non-producing) structures, and 440 auxiliary (never-producing) structures on 1356 active leases; and 329 idle structures and 65 auxiliary structures on 273 inactive leases. The purpose of this paper is to model the impact of alternative regulatory policies on the removal trends of structures and the inventory of idle iron, and to provide first-order estimates of the cost of each regulatory option. A description of the modelling framework and implementation results is presented.

08/02926 On the global warming problem due to carbon dioxide

Lonngren, K. E. and Bai, E.-W. *Energy Policy*, 2008, 36, (4), 1567–1568.
The subject of global warming due to the increased use of fossil fuels is analysed using a modification of the predator prey equations. The results of the calculation indicate that both the fossil fuels and civilization will both become extinct as time increases.

08/02927 Origin and spatial distribution of gas at seismogenic depths of the San Andreas Fault from drill-mud gas analysis

Wiersberg, T. and Erzinger, J. *Applied Geochemistry*, 2008, 23, (6), 1675–1690.
Data are presented on the molecular composition of drill-mud gas from the lower sedimentary section (1800–3987 m) of the SAFOD (San Andreas Fault Observatory at Depth) Main Hole measured on-line during drilling, as well as C and H isotope data from off-line mud gas samples. Hydrocarbons, H_2 and CO_2 are the most abundant non-atmospheric gases in drill-mud when drilling seismogenic zones. Gas influx into the well at depth is related to the lithology and permeability of the drilled strata: larger formation gas influx was detected when drilling through organic-rich shales and permeable sandstones. The SAF (San Andreas Fault), encountered between approximately 3100 m and 3450 m borehole depth, is generally low in gas, but is encompassed by two gas-rich zones (2700–2900 m and below 3550 m) at the fault margins with enhanced ^{222}Rn activities and distinct gas compositions. Within the fault, two interstratified gas-rich lenses (3150–3200 m and 3310–3340 m) consist of CO_2 and hydrocarbons (upper zone), but almost exclusively of hydrocarbons (lower zone). The isotopic composition indicates an organic source of hydrocarbons and CO_2 in the entire sedimentary section of the well. Hydrocarbons in sedimentary strata are partly of microbial origin down to 2500 m borehole depth. The contribution of thermogenic gas increases between 2500 m and 3200 m. Below 3200 m, hydrocarbons fully derive from thermal degradation of organic matter. The lack of H_2 in the center of the fault and the high concentration of H_2 in the fractured zones at the fault margins are consistent with H_2 formation by interaction of water with fresh silica mineral surfaces generated by tectonic activities, however, this needs to be verified by laboratory experiments. Based on these studies, it is concluded that the fault zone margins consist of strata with enhanced permeability, separated by a low-permeability fault centre.

08/02928 System-level hazard analysis using the sequence-tree method

Huang, H.-W. *et al. Annals of Nuclear Energy*, 2008, 35, (3), 353–362.
A system-level preliminary hazard analysis (PHA) using the sequence-tree method is presented to perform safety-related digital instrumentation and control (I&C) system software safety analysis (SSA). The conventional PHA involves brainstorming among experts on various portions of the system to identify hazards through discussions. However, since the conventional PHA is not a systematic technique, the analysis results depend strongly on the experts’ subjective opinions. The quality of analysis cannot be appropriately controlled. Therefore, this study presents a system-level sequence tree based PHA, which can clarify the relationship among the major digital I&C systems. This sequence-tree-based technique has two major phases. The first phase adopts a table to analyse each event in the safety analysis report (SAR) Chapter 15 for a specific safety-related I&C system, such as reactor protection system (RPS). The second phase adopts a sequence tree to recognize the I&C systems involved in the event, the working of the safety-related systems and how the backup systems can be activated to mitigate the consequence if the primary safety systems fail. The defense-in-depth echelons, namely the control echelon, reactor trip echelon, engineered safety featured actuation system (ESFAS) echelon and monitoring and indicator echelon, are arranged to build the sequence-tree structure. All the related I&C systems, including the digital systems and the analog back-up systems, are allocated in their specific echelons. This system-centric sequence-tree analysis not only systematically identifies preliminary hazards, but also vulnerabilities in a nuclear power plant. Hence, an effective simplified D3 evaluation can also be conducted.

08/02929 The clean development mechanism and the international diffusion of technologies: an empirical study

Dechezleprêtre, A. *et al. Energy Policy*, 2008, 36, (4), 1273–1283.
The clean development mechanism (CDM) is expected to stimulate the North–South transfer of climate-friendly technologies. This paper provides an assessment of the technology transfers that take place through the CDM using a data set of 644 registered projects. It provides a detailed description of the transfers (frequency, type, by

sector, by host country, etc.). It also includes an econometric analysis of their drivers. It is shown that transfer likeliness increases with the size of the projects. The transfer probability is 50% higher in projects implemented in a subsidiary of Annex 1 companies while the presence of an official credit buyer has a lower – albeit positive – impact. The analysis also yields interesting results on how technological capabilities of the host country influence technology diffusion in the CDM.

08/02930 The costs of failure: a preliminary assessment of major energy accidents, 1907–2007

Sovacool, B. K. *Energy Policy*, 2008, 36, (5), 1802–1820.

A combination of technical complexity, tight coupling, speed, and human fallibility contribute to the unexpected failure of large-scale energy technologies. This study offers a preliminary assessment of the social and economic costs of major energy accidents from 1907 to 2007. It documents 279 incidents that have been responsible for $41 billion in property damage and 182,156 deaths. Such disasters highlight an often-ignored negative externality to energy production and use, and emphasize the need for further research.

08/02931 The non-linear link between electricity consumption and temperature in Europe: a threshold panel approach

Bessec, M. and Fouquau, J. *Energy Economics*, 2008, 30, (5), 2705–2721.

This paper investigates the relationship between electricity demand and temperature in the European Union. This issue is addressed by means of a panel threshold regression model on 15 European countries over the last two decades. The results confirm the non-linearity of the link between electricity consumption and temperature found in more limited geographical areas in previous studies. By distinguishing between North and South countries, the authors also find that this non-linear pattern is more pronounced in the warm countries. Finally, rolling regressions show that the sensitivity of electricity consumption to temperature in summer has increased in the recent period.

08/02932 Understanding the role of energy consumption in human development through the use of saturation phenomena

Martínez, D. M. and Ebenhack, B. W. *Energy Policy*, 2008, 36, (4), 1430–1435.

A correlation is presented between the UN human development index and per capita energy consumption for 120 nations. A strong relationship between index values and energy consumption is observed for the majority of the world. Additionally, a distinct secondary trend emerges from the dataset, representing heavy energy exporters such as the Organization of the Petroleum Exporting Countries and some Former Soviet Union nations, among others. The preliminary observation is made that these two trends closely resemble saturation curves, exhibited by a variety of natural phenomena. For the primary trend, three regions are isolated: a steep rise in human development relative to energy consumption for energy-poor nations; a moderate rise for transitioning nations; and essentially no rise in human development for energy-advantaged nations, consuming large amounts of modern energy. These correlations suggest that tremendous gains in human development are possible for the world's poorest, with small incremental access to energy.

08/02933 What does Europe pay for clean energy? – review of macroeconomic simulation studies

Dannenberg, A. *et al. Energy Policy*, 2008, 36, (4), 1318–1330.

This paper analyses the macroeconomic costs of environmental regulation in European energy markets on the basis of existing macroeconomic simulation studies. The analysis comprises the European emissions trading scheme, energy taxes, measures in the transport sector and the promotion of renewable energy sources. It is found that these instruments affect the European economy, in particular the energy-intensive industries and the industries that produce internationally tradeable goods. From a macroeconomic point of view, however, the costs of environmental regulation appear to be modest. The underlying environmental targets and the efficient design of regulation are key determinants for the cost burden.

CO_2, NO_x, SO_2 and particulate emissions

08/02934 Control of CO_2 in a naturally ventilated classroom

Griffiths, M. and Eftekhari, M. *Energy and Buildings*, 2008, 40, (4), 556–560.

The ventilation performance of a naturally ventilated classroom was investigated to monitor the CO_2 levels and compare compliance with new guidelines. Measurements of CO_2 levels were taken for 1 week during the heating season while different ventilation modes were investigated. The classroom was shown to have adequate ventilation to provide compliance with current recommendations although thermal comfort was sometimes compromised. Trickle ventilation provided useful ventilation at a rate of $0.75\,\mathrm{l\,s^{-1}}$ per person. Purge ventilation was shown to reduce the CO_2 concentration by 1000 ppm but would not be sufficient to maintain an acceptable level. Experimental measurements showed that the trickle ventilators provided useful background ventilation at a total classroom rate of $22.9\,\mathrm{l\,s^{-1}}$ or approximately $0.75\,\mathrm{l\,s^{-1}}$ per person which is not enough on its own. Night time use of trickle ventilators for reducing day time CO_2 concentration level is not beneficial since the classroom returns to ambient concentration levels by the time the room is used again. Hence energy savings could be made by reducing the overnight background ventilation during heating period. The teaching staff and pupils control the ventilation into the classrooms by thermal comfort rather than air quality.

08/02935 Design of CO_2 absorption plant for recovery of CO_2 from flue gases of gas turbine

Mofarahi, M. *et al. Energy*, 2008, 33, (8), 1311–1319.

The ongoing human-induced emission of carbon dioxide (CO_2) threatens to change the earth's climate. A major factor in global warming is CO_2 emission from thermal power plants, which burn fossil fuels. One possible way of decreasing CO_2 emissions is to apply CO_2 removal, which involves recovering of CO_2 from energy conversion processes. This study is focused on recovery of CO_2 from gas turbine exhaust of Sarkhun gas refinery power station. The purpose of this study is to recover the CO_2 with minimum energy requirement. Many of CO_2 recovery processes from flue gases have been studied. Among all CO_2 recovery processes which were studied, absorption process was selected as the optimum one, due to low CO_2 concentration in flue gas. The design parameters considered in this regard, are: selection of suitable solvent, solvent concentration, solvent circulation rate, reboiler and condenser duty and number of stages in absorber and stripper columns. In the design of this unit, amine solvent such as, diethanolamine, diglycolamine (DGA), methyldiethanolamine, and monoethanolamine were considered and the effect of main parameters on the absorption and stripping columns is presented. Some results with simultaneous changing of the design variables have been obtained. The results show that DGA is the best solvent with minimum energy requirement for recovery of CO_2 from flue gases at atmospheric pressure.

08/02936 Electric swing adsorption for CO_2 removal from flue gases

Grande, C. A. and Rodrigues, A. E. *International Journal of Greenhouse Gas Control*, 2008, 2, (2), 194–202.

One of the most important sources of CO_2 emissions are the fossil-fuel fired plants for production of electricity. Removal of CO_2 from flue gas streams for further sequestration has been proposed by the International Panel on Climate Change experts as one of the most reliable solutions to mitigate anthropogenic greenhouse emissions. When natural gas is employed as fuel, the molar fraction of CO_2 in the flue gas is lower than 5% causing serious problems for capture. The purpose of this work is to present experimental validation of an Electric Swing Adsorption (ESA) technology that may be employed for carbon capture for low molar fractions of CO_2 in the flue gas streams. To improve energy utilization, an activated carbon honeycomb monolith with low electrical resistivity was employed as selective adsorbent. A mathematical model for this honeycomb is proposed as well as different ESA cycles for CO_2 capture.

08/02937 Emissions from a diesel–bioethanol blend in an automotive diesel engine

Lapuerta, M. *et al. Fuel*, 2008, 87, (1), 25–31.

Diesel emissions have been measured from an automotive engine using anhydrous bioethanol blended with conventional diesel, with 10% ethanol in volume and no additives. The resulting emissions have been compared with those from pure diesel. A stationary engine test bed, together with the instrumentation for measuring the most stringent regulated emissions (nitric oxides, total hydrocarbons and particulate matter) and the particle size distributions, allowed to study the effect of this blend on the engine performance and emissions under five different steady state operating conditions, selected from the transient cycle for light duty vehicles established in the European Emission Directive 70/220. Both the consideration of the thermochemical properties of the tested fuels and the computations of a chemical equilibrium model were helpful for the results analysis. These results proved that the use of this renewable component provides a significant reduction on particulate emissions, with no substantial increase in other gaseous emissions, which makes it helpful for contributing, on the one hand, to fulfil the European compromise of using more than

5.75% biofuels in 2010, and on the other hand, to stop the increase in particulate emissions caused by transportation as a consequence of the unceasing dieselization.

08/02938 Green house gases emissions in the production and use of ethanol from sugarcane in Brazil: the 2005/2006 averages and a prediction for 2020

Macedo, I. C. *et al. Biomass and Bioenergy*, 2008, 32, (7), 582–595.

This work presents the evaluation of energy balance and GHG emissions in the production and use of fuel ethanol from cane in Brazil for 2005/2006 (for a sample of mills processing up to 100 million tons of sugarcane per year), and for a conservative scenario proposed for 2020. Fossil energy ratio was 9.3 for 2005/2006 and may reach 11.6 in 2020 with technologies already commercial. For anhydrous ethanol production the total GHG emission was 436 kg CO_2 eq m^{-3} ethanol for 2005/2006, decreasing to 345 kg CO_2 eq m^{-3} in the 2020 scenario. Avoided emissions depend on the final use: for E100 use in Brazil they were (in 2005/2006) 2181 kg CO_2 eq m^{-3} ethanol, and for E25 they were 2323 kg CO_2 eq m^{-3} ethanol (anhydrous). Both values would increase about 26% for the conditions assumed for 2020 mostly due to the large increase in sales of electricity surpluses. A sensitivity analysis has been performed (with 2005/2006 values) to investigate the impacts of the huge variation of some important parameters throughout Brazilian mills on the energy and emissions balance. The results have shown the high impact of cane productivity and ethanol yield variation on these balances (and the impacts of average cane transportation distances, level of soil cultivation, and some others) and of bagasse and electricity surpluses on GHG emissions avoidance.

08/02939 Greenhouse gas emissions trading among Pacific Rim countries: an analysis of policies to bring developing countries to the bargaining table

Rose, A. and Wei, D. *Energy Policy*, 2008, 36, (4), 1420–1429.

This paper examines the aggregate net costs and individual country cost savings of greenhouse gas emissions trading among Pacific Rim countries. The authors propose emission permit allocation rules designed to entice developing countries to participate. Absence of developing country involvement has served as an excuse for the lack by participation by the United States in the first compliance period of the Kyoto Protocol and may serve as a disincentive to even more countries in subsequent periods. The analysis specifies permit allocation rules that could result in no net costs, and even cost-savings, to developing countries for their involvement in the emissions trading market, while at the same time providing extensive benefits to industrialized countries through access to lower-cost mitigation alternatives.

08/02940 Inter-comparison of receptor models for PM source apportionment: case study in an industrial area

Viana, M. *et al. Atmospheric Environment*, 2008, 42, (16), 3820–3832.

Receptor modelling techniques are used to identify and quantify the contributions from emission sources to the levels and major and trace components of ambient particulate matter (PM). A wide variety of receptor models are currently available, and consequently the comparability between models should be evaluated if source apportionment data are to be used as input in health effects studies or mitigation plans. Three of the most widespread receptor models [principal component analysis (PCA); positive matrix factorization (PMF); chemical mass balance (CMB)] were applied to a single PM_{10} data set ($n = 328$ samples, 2002–2005) obtained from an industrial area in NE Spain, dedicated to ceramic production. Sensitivity and temporal trend analyses (using the Mann–Kendall test) were applied. Results evidenced the good overall performance of the three models ($r^2 > 0.83$ and $> 0.91\times$between modelled and measured PM_{10} mass), with a good agreement regarding source identification and high correlations between input (CMB) and output (PCA, PMF) source profiles. Larger differences were obtained regarding the quantification of source contributions (up to a factor of 4 in some cases). The combined application of different types of receptor models would solve the limitations of each of the models, by constructing a more robust solution based on their strengths. The authors suggest the combined use of factor analysis techniques (PCA, PMF) to identify and interpret emission sources, and to obtain a first quantification of their contributions to the PM mass, and the subsequent application of CMB. Further research is needed to ensure that source apportionment methods are robust enough for application to PM health effects assessments.

08/02941 MICS-Asia II: model intercomparison and evaluation of particulate sulfate, nitrate and ammonium

Hayami, H. *et al. Atmospheric Environment*, 2008, 42, (15), 3510–3527.

Eight chemical transport models participate in a model intercomparison study for East Asia, MICS-Asia II. This paper analyses calculated results for particulate matter of sulfate, nitrate and ammonium through comparisons with each other and with monthly measurements at EANET (the acid deposition monitoring network in East Asia) and daily measurements at Fukue, Japan. To the EANET measurements, model ensemble means better agree with model individual results for sulfate and total ammonium, although total nitrate is consistently and considerably underestimated. To measurements at Fukue, the models show better agreement than for the EANET measurements. This is likely because Fukue is centered in many of the model domains, whereas the EANET stations are mostly in Southeast Asia and Russia. Moreover, it would be important that Fukue is in Northeast Asia, where the emission inventory is more reliable than Southeast Asia. The model–model comparisons are made in view of the total amount in the atmosphere, vertical profile, coefficient of variation in surface concentrations, and transformation changes with distance. All the models show reasonable tendencies in vertical profiles and composition ratios. However, total amounts in the atmosphere are discrepant among the models. The consistency of the total amount in the atmosphere would influence source–receptor analysis. It seems that model results would be consistent, if the models take into account the primitive processes like emission, advection/diffusion, chemical transformation and dry/wet deposition, no matter the processes are modelled simply or comprehensively. Through the comparison study, it was learned that it would be difficult to find any problems from one comparison (model-observation comparison with one data or many but at one station or in a short period). Modelers tend to examine model performances only from model-observation comparisons. However, taking budget in a certain or whole model domain would be important, before the models are applied to source–receptor analysis.

08/02942 NO_x removal from the flue gas of oil-fired boiler using a multistage plasma-catalyst hybrid system

Park, S. Y. *et al. Fuel Processing Technology*, 2008, 89, (5), 540–548.

The study on removal of NO_x from the flue gas of oil-fired boiler has been carried out using non-thermal plasma cum catalyst hybrid reactor at 150 °C. Propylene (C_3H_6) was used as a reducing agent. A multistage plasma-catalyst hybrid reactor was newly designed and successfully operated to clean up the flue gas stream having a flow rate of 30 Nm^3/h. TiO_2 and Pd/ZrO_2 wash-coated on cordierite honeycomb were used as catalysts in the present study. Though the plasma-catalyst hybrid reactor with TiO_2 showed good activity on the removal of NO yet it removed only 50–60% of NO_x because a significant portion of NO oxidized to NO_2. On the contrary, the plasma-catalyst hybrid reactor with Pd/ZrO_2 removed about 50% of inlet NO with a negligible amount of NO oxidation into NO_2. The plasma/dual-catalysts hybrid system (front two units of plasma-Pd/ZrO_2 + rear two units of plasma/TiO_2) proved to be very promising in NO_x removal in the presence of C_3H_6. De NO_x efficiency of about 74% has been achieved at a space velocity of 3300/h at 150 °C.

08/02943 Particulate matter emission by a vehicle running on unpaved road

Williams, D. S. *et al. Atmospheric Environment*, 2008, 42, (16), 3899–3905.

The particulate matter (PM) emission from unpaved roads starts with the pulverization of surface material by the force of the vehicle, uplifting and subsequent exposure of road to strong air currents behind the wheels. The objectives of the project were to: demonstrate the utility of a simple technique for collecting suspended airborne PM emitted by vehicle running on an unpaved road, determine the mass balance of airborne PM at different heights, and determine the particle size and elemental composition of PM. Dust samples were collected on sticky tapes using a rotorod sampler mounted on a tower across an unpaved road located at the Leyendecker Plant Sciences Research Center, Las Cruces, NM, USA. Dust samples were collected at 1.5, 4.5 and 6 m height above the ground surface on the east and west side of the road. One rotorod sampler was also installed at the centre of the road at 6 m height. Dust samples from unpaved road were mostly (70%) silt and clay-sized particles and were collected at all heights. The height and width of the PM plume and the amount of clay-sized particles captured on both sides of the road increased with speed and particle captured ranged from 0.05 to 159 μm. Dust particles between PM_{10} and $PM_{2.5}$ did not correlate with vehicle speed but particles $\geq PM_{2.5}$ did. Emission factors estimated for the total suspended PM were 10,147 g km^{-1} at 48 km h^{-1} and 11,062 g km^{-1} at 64 km h^{-1} speed, respectively. The predominant elements detected in PM were carbon, aluminum and silica at all heights. Overall, sticky tape method coupled with electron microscopy was a useful technique for a rapid particle size and elemental characterization of airborne PM.

08/02944 Particulate-associated potentially harmful elements in urban road dusts in Xi'an, China

Han, Y. *et al. Applied Geochemistry*, 2008, 23, (4), 835–845.

Sixty-five urban road dust samples were collected from different land use areas of 240 km^2 in Xi'an, China. The concentrations of Ag, As, Cr, Cu, Hg, Pb, Sb and Zn were determined to investigate potentially harmful element contamination, distribution and possible sources. In addition, the concentrations in different size fractions were measured to assess their potential impact on human health. The highest concentrations were found in the fraction with particle diameters between 80 µm and 101 µm, the finest particles (<63 µm) were not the most important carriers for Ag, As, Cd, Cr, Cu, Hg, Pb and Zn. The percentages of these elements in particles with diameters less than 63 µm (PM_{63}) and less than 101 µm (PM_{101}) were in the range of 7–15%, and 30–55%, respectively. Three main factors influencing element distributions have been identified: (a) industrial activities; (b) prior agricultural land use; and (c) other activities commonly found in urban areas, such as traffic, coal combustion, waste dumping, and building construction/renovation. The highest concentrations were found in industrial areas for As (20 mg kg^{-1}), Cr (853 mg kg^{-1}), Cu (1071 mg kg^{-1}), Pb (3060 mg kg^{-1}) and Zn (2112 mg kg^{-1}), and in previous agricultural areas for Ag and Hg, indicating significant contributions from industrial activities and prior agricultural activities.

08/02945 Reservoir simulation of CO_2 sequestration pilot in Frio brine formation, USA Gulf Coast

Ghomian, Y. *et al. Energy*, 2008, 33, (7), 1055–1067.

Reservoir simulation studies were performed to investigate compositional effects between aquifer fluid (brine) and injected supercritical CO_2 during the sequestration process in the Frio brine formation. Accurate data calibrations of CO_2 solubility and density, as well as brine density and viscosity, were performed. Hysteresis relative permeability was taken into consideration to account for the effect of trapped gas in the aquifer. In addition, real aquifer data obtained from the test site were used in order to characterize the Frio aquifer. The Frio Brine Storage Project is a study in the USA that was conducted by the Bureau of Economic Geology (BEG) at the University of Texas at Austin as a pilot to investigate the CO_2 sequestration process in an aquifer as the first closely monitored case study. The objective of monitoring this pilot study, which was conducted by a collaboration of several research organizations was to observe the behaviour of supercritical CO_2 in the subsurface, investigate the physics of the process, and obtain data for further validation of simulation results. This simulation study was carried out before the pilot began, and the results were verified against the early results of the field experiment. Different scenarios were simulated to investigate the lateral and vertical spread of the CO_2 plume in the aquifer. Local grid refinement around both injection and monitoring wells helped to obtain accurate results. According to the studies, at the end of the simulation period (10 years from the injection date), a significant part of the injected CO_2 will be in the form of trapped gas or will be dissolved in the aqueous phase. Considering the proposed injection plan, and since only a small portion of the injected CO_2 will be in the form of free gas, the possibility of CO_2 escape through the shale cap rock will be very low.

Hydrocarbon emissions

08/02946 Characterization of molecular markers in smoke from residential coal combustion in China

Bi, X. *et al. Fuel*, 2008, 87, (1), 112–119.

The organic constituents and distributions of molecular markers emitted from a residential coal-stove burning honeycomb coal briquettes were determined in this study. The major organic components emitted directly in smoke particles were polycyclic aromatic hydrocarbons (PAHs), with abundant hydroxy-polycyclic aromatic hydrocarbons (OH-PAHs), i.e. thermally altered derivative compounds from coal combustion, UCM (unresolved complex mixture of branched and cyclic compounds), *n*-alkanes and *n*-alkanoic acids. Other compounds present as minor components included *n*-alkenes, phenols, alkylbenzenes and *n*-alkanols. The distributions of the organic compounds in the coal smoke samples were highly variable and dependent on combustion temperature, flame aeration, fire duration, and coal rank. Coal smoke emissions may be identified by some indicators including: (1) presence of hydroxy-PAHs, (2) the decrease in carbon preference index (CPI) of *n*-alkanoic acids with increasing rank, (3) the decrease of the ratios of 17α(H),21β(H)-29-norhopane to 22R-17α(H),21β(H)-homohopane and 17α(H),21β(H)-29-norhopane to 17α(H),21β(H)-hopane with increasing rank, (4) the increases in the homohopane index [22S/(22S + 22R)] and the 17α(H),21β(H)-hopane to 17β(H), 21α(H)-hopane ratio with increasing rank, and (5) the increase of benzo[*e*]pyrene/(benzo[*e*]pyrene + benzo[*a*]pyrene) with increasing rank. In addition, the diagnostic ratios among PAHs and between PAHs and the corresponding hydroxy-PAHs, such as benz[*a*]anthracene/(benz[*a*]anthracene + chrysene), indeno[1,2,3-*cd*]pyrene/(indeno[1,2,3-*cd*]pyrene + benzo[*ghi*]perylene), pyrene/OH-pyrene, and chrysene/OH-chrysene can be used to distinguish bituminous from anthracite coal smoke emissions.

08/02947 Implications of changing urban and rural emissions on non-methane hydrocarbons in the Pearl River Delta region of China

Tang, J. H. *et al. Atmospheric Environment*, 2008, 42, (16), 3780–3794.

Guangzhou (GZ) is one of the highly industrialized and economically vibrant cities in China, yet it remains relatively understudied in terms of its air quality, which has become severely degraded. In this study, extensive air sampling campaigns had been conducted at GZ urban sites and in Dinghu Mountain (DM), a rural site, in the Pearl river delta (PRD) during the spring of 2001 and 2005. Additionally, roadside and tunnel samples were collected in GZ in 2000 and 2005. Later, exhaust samples from liquefied petroleum gas (LPG)- and gasoline-fueled taxis were collected in 2006. All samples were analysed for C_2–C_{10} non-methane hydrocarbons (NMHCs). NMHC profiles showed significant differences in the exhaust samples between gasoline- and LPG-fueled taxis. Propane (47%) was the dominant hydrocarbon in the exhaust of the LPG-fueled taxis, while ethene (35%) was the dominant one in that of gasoline-fueled taxis. The use of LPG-fueled buses and taxis since 2003 and the leakage from these LPG-fueled vehicles were the major factors for the much higher level of propane in GZ urban area in 2005 compared to 2001. The mixing ratios of toluene, ethylbenzene, *m*/*p*-xylene and *o*-xylene decreased at the GZ and DM sites between 2001 and 2005, especially for toluene in GZ, despite the sharp increase in the number of registered motor vehicles in GZ. This phenomenon was driven in part by the closure of polluting industries as well as the upgrading of the road network in urban GZ and in part by the implementation of more stringent emission standards for polluting industries and motor vehicles in the PRD region.

08/02948 Photocatalysis of 4-chlorophenol mediated by TiO_2 fixed to concrete surfaces

Watts, M. J. and Cooper, A. T. *Solar Energy*, 2008, 82, (3), 206–211.

Titanium dioxide (TiO_2) powder was mixed with varying concrete sealer formulations and applied to prepared concrete surfaces within PVC batch reactors. A solution of 4-chlorophenol in de-ionized water, with an initial 4-chlorophenol concentration of 4 mg/L, was added to each open reactor. The photocatalytic efficiency of each TiO_2-sealer was determined through bulk solution sampling while a reactor was exposed to continuous UV light. Through analysis of mean 4-chlorophenol concentrations, the disappearance of 4-chlorophenol from solution was attributed solely to the presence of TiO_2 in the sealed concrete surface of a UV exposed reactor. The rate of disappearance increased when the mass percent of TiO_2 in the sealer was increased. The zero-order reaction rate constants ranged from 0.135 to 0.2873 mg L^{-1} h^{-1}.

Life cycle analysis

08/02949 Embodied and operational carbon dioxide emissions from housing: a case study on the effects of thermal mass and climate change

Hacker, J. N. *et al. Energy and Buildings*, 2008, 40, (3), 375–384.

A 100-year lifecycle carbon dioxide (CO_2) emissions analysis is reported for a two-bedroom, 65 m^2 floor area, semi-detached house in south-east England. How the balance between the embodied (ECO_2) and operational CO_2 emissions of the building are affected by the inclusion of thermal mass and the impacts of climate change is quantified. Four 'weights' of thermal mass were considered, ranging from lightweight timber frame to very heavyweight concrete construction. For each case, total ECO_2 quantities were calculated and predictions for operational CO_2 emissions obtained from a 100-year dynamic thermal modelling simulation under a medium-high emissions climate change scenario for south-east England. At the start of the lifecycle, the dwellings were passively cooled in summer, but air conditioning was installed when overheating reached a certain threshold. The inclusion of thermal mass delayed the year in the lifecycle when this occurred, due to the better passive control of summertime overheating. Operational heating and cooling energy needs were also found to decrease with increasing thermal mass due to the beneficial effects of fabric energy storage. The calculated initial ECO_2 was higher in the heavier weight cases, by up to 15% (4.93 t) of the lightweight case value, but these difference were offset early in the lifecycle due to the savings in operational CO_2 emissions, with total savings of up to 17% (35.7 t) in lifecycle CO_2 found for the heaviest weight case.

08/02950 Life cycle assessment of residential heating and cooling systems in four regions in the United States

Shah, V. P. *et al. Energy and Buildings*, 2008, 40, (4), 503–513.

Heating and cooling systems consume the most energy and are the largest source of emissions in the entire life cycle of a house. This study compares the life cycle impacts of three residential heating and cooling systems – warm-air furnace and air-conditioner, hot water boiler and air-conditioner, and air–air heat pump over a 35-year study period. Simulation and life cycle assessment studies of the systems at four locations in the United States, namely Minnesota, Oregon, Pennsylvania and Texas determine the effect of regional variations in climate, energy mix, and the standard building characteristics on the systems' environmental impacts. In Minnesota, Pennsylvania, and Texas, the heat pump has the highest impacts whereas in Oregon the heat pump has the lowest impacts. A second scenario shows that substitution by high-efficiency equipment reduces the impacts of all systems but does not affect the order of relative performance by region. Another scenario examined the replacement of coal-generated electricity by renewable generation in regional grids. In order to reduce the impacts of the heat pump system to the lowest of the three systems, renewable sources would have to replace 42% of electricity generation in Minnesota, 15% in Pennsylvania, and 38% in Texas.

08/02951 Life cycle of hydroprocessing catalysts and total catalyst management

Eijsbouts, S. *et al. Catalysis Today*, 2008, 130, (2–4), 361–373.

Hydroprocessing catalysts based on Ni, Co, Mo and W are used in various refinery processing applications where several deactivation mechanisms become of importance (coke formation, active phase sintering, metals deposition, poisoning) in the catalyst's life cycle. The life cycle of commercial hydroprocessing catalysts is very complex and includes the catalyst production, sulfidation, use, oxidative regeneration followed by re-sulfidation and reuse or, if reuse is not possible, recycling or disposal. To understand the changes in catalyst properties taking place during a life cycle, the catalyst quality in the different stages can be best monitored by using advanced analytical techniques. The catalyst's life cycle is further complicated by numerous technical, environmental and organizational issues involved. In principle, different companies can be involved in each of the life cycle steps. Leading catalyst manufacturers, together with specialized firms, offer refineries a total catalyst management concept, starting with the purchase of the fresh catalyst and ending with its final recycling or disposal. Total catalyst management includes a broad range of services, ensuring optimal timing during the change-out process, reliable, smooth and safe operations, minimal downtime and maximum catalyst and unit performance.

16 ENERGY

Supplies, policy, economics, forecasts

08/02952 A forecast of household ownership and use of alternative fuel vehicles: a multiple discrete-continuous choice approach

Ahn, J. *et al. Energy Economics*, 2008, 30, (5), 2091–2104.

The paper analyses how adding alternative fuel passenger cars to the market will affect patterns in demand for passenger cars. Conjoint analysis and a multiple discrete-continuous choice model are used to estimate consumer preferences regarding alternative fuel vehicles, and based on the estimates, a simulation was conducted to analyse changing rates of ownership and use of variously fueled passenger cars under the effect of the introduction of alternative fuel passenger cars. In addition, the authors estimate changes in overall fuel consumption and the emission of pollutants. The results show that gasoline-fueled cars will still be most consumers' first choice, but alternative fuel passenger cars will nevertheless compete and offer a substitute for the purchase and use of gasoline-fueled or diesel-fueled cars. Finally, results show that adding alternative fuel cars to the market would effectively lower gasoline and diesel fuel consumption and the emission of pollutants.

08/02953 A note on the conditional correlation between energy prices: evidence from future markets

Marzo, M. and Zagaglia, P. *Energy Economics*, 2008, 30, (5), 2454–2458.

In this paper, the authors model the joint movements of daily returns on one-month futures for crude oil, heating oil and natural gas through the multivariate GARCH with dynamic conditional correlations and elliptical distributions introduced by Pelagatti and Rondena. Futures prices of crude and heating oil covary strongly. The conditional correlation between the futures prices of natural gas and crude oil has been rising over the last 5 years. However, this correlation has been low on average over two thirds of the sample, suggesting that future markets have no established tradition of pricing natural gas as a function of developments on oil markets.

08/02954 A novel crazy swarm optimized economic load dispatch for various types of cost functions

Roy, R. and Ghoshal, S. P. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (4), 242–253.

Economic load dispatch (ELD) is the scheduling of generators to minimize the total operating cost depending on equality and inequality constraints. The transmission line loss also is to be kept as minimum as possible. So, the problem is of multi-objective optimization. The authors have studied the comparative effectiveness of GA, improved fast EP (IFEP) and various particle swarm optimizations (PSO) reported in the literature and a novel particle swarm algorithm namely CRAZYPSO for such multi-objective optimization in two test cases. The first test case deals with some well-known benchmark functions and then the second case deals with a general power system having 40 thermal generating units with non-monotonically increasing cost functions with valve point loadings and other constraints. The generators are interconnected through lossy transmission lines. The proposed method out performs and provides true global optimal solutions as compared to other existing techniques for economic load dispatch.

08/02955 A statistical method to investigate national energy consumption in the residential building sector of China

Chen, S. *et al. Energy and Buildings*, 2008, 40, (4), 654–665.

The frame of a national statistical system of residential energy consumption for China is presented in this paper, according to current status of the climate, social and historic conditions, and energy consumption characteristics in the five architecture climate divisions in China. The statistical index system of residential energy consumption is constituted which refers to housing unit characteristics, household characteristics, possession and utilization of energy consuming equipment, and residential energy consumption quantities. This index system suits for all the different utilization structures of residential energy consumption in different architecture climate divisions. On this base, a complete set of statistical reports is worked out to measure the energy consumption of cities, provinces and the country stage by stage. Finally the statistical method above is applied to measure residential energy consumption by case studies, in order to validate the feasibility of this method. The research in this paper covers the first step of the elaboration of the statistical method to investigate energy consumption in China, and more work will be done in future to further impel national statistics of residential energy consumption.

08/02956 A study on estimating the energetic and exergetic prices of various residential energy sources

Hepbasli, A. *Energy and Buildings*, 2008, 40, (3), 308–315.

In choosing the type of any energy sources for residential and other uses, their prices play in general a big role. These prices are based on energy values. Besides this, the application of the exergy, which is a way to a sustainable future, is more meaningful in providing information for long-term planning of resource management. In the present study, energy and exergy prices of various energy sources are investigated. The energy sources considered include coal, natural gas, furnace oil, diesel oil, liquefied petroleum gas and wood, while electric resistance along with heat pump and district heating are also covered. In this context, chemical exergy relations of these energy sources are presented first. The prices of various energy sources in the Turkish residential sector, which is given as an illustrative example, are then used in the calculations. Finally, the energy and exergy prices are compared with each other, while the main conclusions are listed. The highest unit energy price is that of diesel oil, while the lowest one is that of natural gas. The differences between the energy and exergy prices are small for all energy carriers.

08/02957 An empirical study on the rebound effect considering capital costs

Mizobuchi, K. *Energy Economics*, 2008, 30, (5), 2486–2516.

Technological progress is one of the means of reducing energy usage and carbon dioxide (CO_2) emissions. However, this reduction, in turn, leads to a reduction in the real cost of energy services per unit, which results in an increase in the demand for energy services. Therefore, a reduction in the anticipated CO_2 emissions caused by a technological improvement might be partially offset in response to the cost reduction. Previous studies have referred to this effect as the 'rebound effect'. A large amount of empirical evidence on the rebound effect exists; however, most of these studies assume an exogenous improvement in energy efficiency, and thus, capital costs that may decrease the magnitude of the rebound effect are not taken into account expressly. This paper extends the scope of the research conducted by Brannlund *et al.* in terms of two aspects: (i) considering capital costs explicitly as additional capital costs and (ii) adapting an iterating procedure, and estimating the rebound effect, using Japanese household data. As a result of the empirical analysis, it is concluded that the rebound is approximately 27%. However, it is also found that ignoring additional capital costs leads to an increase in the rebound effect. In the case of Japanese households, the magnitude of the rebound effect increases to approximately 115%. Moreover, the simulation study shows that only a one-time iteration of Brannlund *et al.* may lead to a biased result.

08/02958 Armington elasticities for energy policy modeling: evidence from four European countries

Welsch, H. *Energy Economics*, 2008, 30, (5), 2252–2264.

Elasticities of substitution among imports and competing domestic production (Armington elasticities) play an important role in computable general equilibrium assessments of energy and climate policy. This paper provides estimates of Armington elasticities for 15 commodity groups in four European countries. Since Armington elasticities are found to be rather low on average, researchers may want to reconsider the device of using high values of Armington elasticities in CGE models to avoid unrealistic competitiveness effects or emission leakage rates associated with energy or carbon taxes or other forms of energy-related regulation. Estimated elasticities tend to be higher in the case of machinery and other investment goods than in the case of primary products, ores and chemicals, as well as consumer goods.

08/02959 China's energy economy: technical change, factor demand and interfactor/interfuel substitution

Ma, H. *et al. Energy Economics*, 2008, 30, (5), 2167–2183.

With its rapid economic growth, China's primary energy consumption has exceeded domestic energy production since 1994, leading to a substantial expansion in energy imports, particularly of oil. China's energy demand has an increasingly significant impact on global energy markets. In this paper Allen partial elasticities of factor and energy substitution, and price elasticities of energy demand, are calculated for China using a two-stage translog cost function approach. The results suggest that energy is substitutable with both capital and labour. Coal is significantly substitutable with electricity and complementary with diesel while gasoline and electricity are substitutable with diesel. China's energy intensity is increasing during the study period (1995–2004) and the major driver appears to be due to the increased use of energy-intensive technology.

08/02960 Codes for solar flux calculation dedicated to central receiver system applications: a comparative review

Garcia, P. *et al. Solar Energy*, 2008, 82, (3), 189–197.

As adapted software is needed to calculate the solar flux concentration through a tower-heliostat field system, an overview of computer codes was performed, detailing their features, strengths and weaknesses. For this a questionnaire was sent to developers or heavy users of codes that are currently used in the concentrated solar power (CSP) community. Answers to this questionnaire make it possible to determine which tool is relevant depending on the objectives of the simulation. Modelling tools for central receiver systems (CRS) can be divided into two main categories, corresponding to two kinds of problems: on one hand those dedicated to system optimization and on the other hand those designed to detailed analysis of the optical performances. A bibliographic study on first generation and developing codes complements this overview of tools that may be interesting for CSP research or industry.

08/02961 Development of energy performance benchmarks and building energy ratings for non-domestic buildings: an example for Irish primary schools

Hernandez, P. *et al. Energy and Buildings*, 2008, 40, (3), 249–254.

The EU Member States are in the process of implementing energy rating procedures for buildings. For non-domestic buildings in particular, devising a robust and cost effective energy rating method is not a simple task. The situation becomes more complicated where countries do not have a tradition of performing energy calculations or undertaking energy measurements in buildings. This paper outlines a methodology to develop energy benchmarks and rating systems starting from the very first step of data collection from the building stock. Methods for rating a sample Irish school according to both calculated and measured ratings are applied, and finally the paper discusses the advantages and disadvantages of the two approaches.

08/02962 Developments in international bioenergy trade

Junginger, M. *et al. Biomass and Bioenergy*, 2008, 32, (8), 717–729.

The aim of this paper is to present a synthesis of the main developments and drivers of international bioenergy trade in IEA Bioenergy Task 40 member countries, based on various country reports written by Task 40 members. Special attention is given to pellet and ethanol trade. In many European countries such as Belgium, Finland, the Netherlands, Sweden and the UK, imported biomass contributes already significantly (between 21% and 43%) to total biomass use. Wood pellets are currently exported by Canada, Finland and (to a small extent) Brazil and Norway, and imported by Sweden, Belgium, the Netherlands, and the UK. In the Netherlands and Belgium, pellet imports nowadays contribute to a major share to total renewable electricity production. Trade in bio-ethanol is another example of a rapidly growing international market. With the EU-wide target of 5.75% biofuels for transportation in 2010 (and 10% in 2020), exports from Brazil and other countries to Europe are likely to rise as well. Major drivers for international bioenergy trade in general are the large resource potentials and relatively low production costs in producing countries such as Canada and Brazil, and high fossil fuel prices and various policy incentives to stimulate biomass use in importing countries. However, the logistic infrastructure both in exporting and importing countries needs to be developed to access larger physical biomass volumes and to reach other (i.e. smaller) end-consumers. It is concluded that international bioenergy trade is growing rapidly, far beyond what was deemed possible only a few years ago, and may in the future in some Task 40 countries surpass domestic biomass use, especially for specific applications (e.g. transport fuels).

08/02963 Energy consumption and economic growth: evidence from 11 sub-Sahara African countries

Akinlo, A. E. *Energy Economics*, 2008, 30, (5), 2391–2400.

The paper examines the causal relationship between energy consumption and economic growth for 11 countries in sub-Saharan Africa. Using the autoregressive distributed lag bounds test, the study finds that energy consumption is cointegrated with economic growth in Cameroon, Cote D'Ivoire, Gambia, Ghana, Senegal, Sudan and Zimbabwe. Moreover, this test suggests that energy consumption has a significant positive long run impact on economic growth in Ghana, Kenya, Senegal and Sudan. Granger causality test based on vector error correction model shows bi-directional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal. However, Granger causality test shows that economic growth Granger causes energy consumption in Sudan and Zimbabwe. The neutrality hypothesis is confirmed in respect of Cameroon and Cote D'Ivoire. The same result of no causality was found for Nigeria, Kenya and Togo. The result shows that each country should formulate appropriate energy conservation policies taking into cognizance of her peculiar condition.

08/02964 Energy-income causality in OECD countries revisited: the key role of capital stock

Lee, C.-C. *et al. Energy Economics*, 2008, 30, (5), 2359–2373.

This paper applies a recent advance in panel analysis to estimate the panel cointegration and panel vector error correction models for a set of 22 Organization for Economic Co-operation and Development (OECD) countries using annual data covering the period 1960–2001. The relationship between energy consumption and income is investigated using an aggregate production function and controlling for the capital stock, as well as by exploring the dynamic directions of the causality among these three variables. The authors firstly obtain solid and convincing evidence of a fairly strong long-run equilibrium relationship among them. Secondly, it is found that the capital stock is much more productive than energy consumption. Third, it is observed that neglecting the impact of the capital stock on income tends to overestimate the effect of energy consumption. Finally, the panel causality test shows bi-directional causal linkages exist among energy consumption, the capital stock and economic growth. Overall, the findings reveal that the capital stock plays a critical role in realizing the dynamic relationship between energy and income.

08/02965 Evaluation of Mexico's 1975–2000 energy plan

Bazán-Perkins, S. D. and Fernández-Zayas, J. L. *Energy Economics*, 2008, 30, (5), 2569–2586.

The certainty and trustworthiness of a planning model can best be assessed when projections can be compared with actual developments. The ability to design scenarios and to evaluate demographic, economic and technological change is also increased with periodic comparisons between plans and actual facts. In 1976, the Mexican government published a 25 year power supply plan for the country, in which a development of non-fossil fuel plants was recommended, largely due to environmental considerations. It was proposed that the new demand should be met mainly with renewable energy sources and nuclear power. The study stated that hydrocarbons would reach a peak between 2003 and 2005, and that after this point the descent of fuel consumption would proceed at an increased velocity. Under this program, the dependence of Mexico on fuel for electricity would be gradually reduced as the twenty-first century progressed. The suggestion was not assumed by successive governments, and fossil fuel plants took the place of the proposed nuclear plants. However, the original 25 years power plan has proved to be quite accurate in its social and economic previsions, and allows the validation of a new, more powerful and reliable planning model. This paper presents the results of the validation of the model, as well as major considerations to be heeded in the future to increase certainty in further planning efforts. The projection of a better, more sustainable and reliable energy future is also proposed.

08/02966 Ex-post evaluation of European energy models

Pilavachi, P. A. *et al. Energy Policy*, 2008, 36, (5), 1726–1735.

Various energy-modelling activities are pursued by public authorities, private companies and research institutes with the aim to provide energy forecasts and to assess the impact of energy and environmental policies. Nevertheless, no *ex-post* evaluations of the results of these modelling activities have been carried out at the European Community level. This paper investigates and compares the assumptions and the results from a European study carried out in the middle of the eighties with the combination of the so-called modèle de prospective de la demande énergétique à long terme (MEDEE) and energy flow optimization (EFOM) models with the targeted year of 2000 as presented in the 'ENERGY 2000' study. Concretely, assumptions and forecasts are compared with real statistical data. In this way, an evaluation of quantitative tools and model results can be established. The aim of this paper is not to evaluate the quantitative tools themselves but their results and their policy relevance within a frame of 15 years.

08/02967 Fuel cell systems for transportation: status and trends

Ahluwalia, R. K. and Wang, X. *Journal of Power Sources*, 2008, 177, (1), 167–176.

The US programme for the development of direct hydrogen-fuelled automotive fuel cell systems has established ambitious performance and cost targets for the 2010 and 2015 time frames. These targets include peak and rated power efficiencies of 60% and 50%, respectively, specific power and power densities of 650 We kg^{-1} and 650 We L^{-1}, and manufactured costs of \$45 and 30 kWe^{-1} for 80 kWe^{-1} net systems in the 2010 and 2015 systems, respectively. In this paper, the use of fuel cell system models is discussed to examine the performance and projected manufactured costs of 2005 systems and the improvements needed to meet the 2010 and 2015 system level targets. It appears possible to meet most of the 2010 performance targets with advances such as the nano-structured thin film electrocatalysts and a modified electrolyte membrane capable of operating at up to 95 °C, at least for short periods. To meet the 2015 targets, however, the fuel cell systems may need to operate without pressurization at higher temperatures of up to 120 °C without the need to humidify the fuel gas and air, along with several other improvements in stack and balance-of-plant components. The simulations provide quantitative estimates of the various performance and cost parameters of the near-term and the advanced systems that can achieve the targets set for automotive fuel cell system development.

08/02968 Input–output analysis of alternative policies implemented on the energy activities: an application for Catalonia

Llop, M. and Pié, L. *Energy Policy*, 2008, 36, (5), 1642–1648.

The aim of this paper is to analyse the economic impact of alternative policies implemented on the energy activities of the Catalan production system. Specifically, the effects of a tax on intermediate energy uses is analysed, a reduction in intermediate energy demand, and a tax on intermediate uses combined with a reduction in intermediate energy demand. The methodology involves two versions of the input–output price model: a competitive price formulation and a mark-up price formulation. The input–output price framework will make it possible to evaluate how the alternative measures modify production prices, consumption prices, private real income, and intermediate energy uses. The empirical application is for the Catalan economy and uses economic data for the year 2001. The combination of a tax on energy uses and an improvement in the energy efficiency of the production system is a measure that accomplishes both economic and environmental goals, since it has no effects on prices, it has a positive effect on private real income and, finally, energy consumption is considerably reduced.

08/02969 Intermediate steps towards the 2000 W society in Switzerland: an energy–economic scenario analysis

Schulz, T. F. *et al. Energy Policy*, 2008, 36, (4), 1303–1317.

In the future, sustainable development under the umbrella of the 2000 W society could be of major interest. Could the target of the 2000 W society, i.e. a primary energy per capita (PEC) consumption of 2000 W, be realized until 2050? Various combinations of PEC and CO_2 targets are tested, and the additional costs to be paid by the society are estimated. The assessment is carried out with the Swiss MARKAL model, a bottom-up energy-system model projecting future technology investments for Switzerland. The analysis reveals that the 2000 W society should be seen as a long-term goal. For all contemplated scenarios, a PEC consumption of 3500 W per capita (w/cap) is feasible in the year 2050. However, strong PEC consumption targets can reduce CO_2 emissions to an equivalent of 5% per decade at maximum. For stronger CO_2 emission reduction goals, corresponding targets must be formulated explicitly. At an oil price of 75 US\$$_{2000}$/bbl in 2050, the additional (cumulative, discounted) costs to reach a 10% CO_2 reduction per decade combined with a 3500 W per capita target amount to about 40 billion US\$$_{2000}$. On the contrary, to reach pure CO_2 reduction targets is drastically cheaper, challenging the vision of the 2000 W society.

08/02970 International bioenergy trade in the Netherlands

Junginger, M. *et al. Biomass and Bioenergy*, 2008, 32, (8), 672–687.

The international biomass trade in the Netherlands has been growing strongly over the last few years, but information on the corresponding volumes, origins and prices is barely available. The objectives of this paper are to quantify imported and exported biomass volumes and origins, and identify drivers and barriers behind the trade flows. Data collection was based on existing statistics and information obtained from biomass traders and end-users. Net import of biomass for energy purposes has been increasing from 2.5 PJ in 2003 to above 20 PJ in 2005–2006, consisting mainly of vegetable oils, agricultural residues and wood and wood-derived fuels, used to almost 100% in Dutch coal- and gas-fired power plants. Biomass exports (mainly of waste wood and construction wood) were high in 2004 (an estimated 13.2 PJ) but have probably strongly declined by the end of 2006, while (re)-export of wood pellets has been increasing in recent years, estimated at 5–7 PJ in 2005–2006. The main driver for biomass imports were the Dutch MEP feed-in tariff for electricity from biomass, while difficulties to obtain permits to co-fire (contaminated) waste wood were a main driver for the export of biomass. Rapidly changing feed-in tariff levels and support systems were seen as one of the largest barriers for the development of a stable biomass trade. Other major issues include concerns regarding the sustainability of biomass production, competition with biomass applications for food and fodder and import restrictions. Major additional imports of liquid transportation fuels are expected until 2010, which could possibly increase the import of biomass to over 50 PJ.

08/02971 Legal and regulatory challenges in the implementation of CO_2 geological storage: an Alberta and Canadian perspective

Bachu, S. *International Journal of Greenhouse Gas Control*, 2008, 2, (2), 259–273.

Alberta is the province with the largest CO_2 emissions in Canada, with approximately two-thirds of emissions originating from large stationary sources. Due to the fortuitous association of large CO_2 sources with the storage capacity offered by the underlying Alberta basin, it is expected that large-scale CO_2 geological storage in Canada will occur in Alberta first, and both levels of governments are contemplating measures to facilitate implementation. A review of the current provincial and federal legislation and regulations presented in this paper indicates that the existing legal and regulatory regime is reasonably sufficient, with some modifications, to accommodate the active injection phase of CO_2 capture and storage (CCS) operations, and the early takers of this new technology. However, governments in Alberta and Canada, and likely everywhere, need to address several pressing issues dealing mainly with the CCS post-operational phase. These issues, reviewed in this paper from an Alberta and Canadian perspective, fall into several categories: jurisdictional, property (ownership), regulatory and liability. Because Alberta is a landlocked province, matters relating to CO_2 storage under the seabed will not be addressed here except when discussing matters of jurisdiction and CO_2 classification. Possible models for post-injection liability transfer to the state are also presented. Although this review is focused on western Canada conditions, the issues are broad enough to be of interest in other jurisdictions, which may also adopt parts of the legal and regulatory framework that is quite well developed in Alberta.

08/02972 Measuring the importance of oil-related revenues in total fiscal income for Mexico

Reyes-Loya, M. L. and Blanco, L. *Energy Economics*, 2008, 30, (5), 2552–2568.

Revenues from oil exports are an important part of government budgets in Mexico. A time-series analysis is conducted using monthly data from 1990 to 2005 examining three different specifications to determine how international oil price fluctuations and government income generated from oil exports influence fiscal policy in Mexico. The behaviour of government spending and taxation is consistent with the spend-tax hypothesis. The results show that there is an inverse relationship between oil-related revenues and tax revenue from non-oil sources. Fiscal policy reform is urgently needed in order to improve tax collection as oil reserves in Mexico become more and more depleted.

08/02973 MICS-Asia II: an inter-comparison study of emission inventories for the Japan region

Kannari, A. *et al. Atmospheric Environment*, 2008, 42, (15), 3584–3591.

For the model intercomparison study, MICS Asia phase II, standard air pollutants emission data are provided from published research results (the TRACE-P data set) and other recent work. To provide preliminary information concerning the reliability of the standard emissions data, this inventory was compared with a local emission inventory, EAGrid2000-Japan, which has been developed for detailed analyses with fine grid data resolution for the Japan region. Although these inventories are based upon different estimation methodologies, from the comparative analyses it was found that regional emissions of the standard data are consistent, with differences smaller than 10% for SO_2, NO_x, NMVOC and CO_2, and smaller than 30% for CO and NH_3. Differences for all species are smaller than the 95% confidence intervals that were estimated in the research that produced the standard emissions data. Additional information is provided regarding emissions of PM_{10} and $PM_{2.5}$, although these did not originate in the TRACE-P data. Furthermore, it was found that the $0.5° \times 0.5°$ grid-based emissions from the two inventories match well for NO_x, NMVOC, CO, and $PM_{2.5}$, even though the spatial allocation techniques for the local inventory are much more detailed. For SO_2 emissions, the differences in the grid-based inventories are greater. Although some problems still remain, such as diurnal variations that are not considered in the standard emissions data, the intercomparison analysis suggests that the standard emissions data have appropriate properties for atmospheric model simulation.

08/02974 Multiple timescale analysis and factor analysis of energy ecological footprint growth in China 1953–2006

Chen, C.-C. and Lin, Z.-S. *Energy Policy*, 2008, 36, (5), 1666–1678.

Scientific analysis of energy consumption and its influencing factors is of great importance for energy strategy and policy planning. The energy consumption in China 1953–2006 is estimated by applying the energy ecological footprint (EEF) method, and the fluctuation periods of annual China's per capita EEF (EEF_{cpc}) growth rate are analysed with the empirical mode decomposition (EMD) method in this paper. EEF intensity is analysed to depict energy efficiency in China. The main timescales of the 37 factors that affect the annual growth rate of EEF_{cpc} are also discussed based on EMD and factor analysis methods. Results show three obvious undulation cycles of the annual growth rate of EEF_{cpc}, i.e. 4.6, 14.4 and 34.2 years over the last 53 years. The analysis findings from the common synthesized factors of IMF1, IMF2 and IMF3 timescales of the 37 factors suggest that China's energy policy-makers should attach more importance to stabilizing economic growth, optimizing industrial structure, regulating domestic petroleum exploitation and improving transportation efficiency.

08/02975 Oil price shocks and stock markets in the U.S. and 13 European countries

Park, J. and Ratti, R. A. *Energy Economics*, 2008, 30, (5), 2587–2608.

Oil price shocks have a statistically significant impact on real stock returns contemporaneously and/or within the following month in the USA and 13 European countries over 1986:1–2005:12. Norway as an oil exporter shows a statistically significantly positive response of real stock returns to an oil price increase. The median result from variance decomposition analysis is that oil price shocks account for a statistically significant 6% of the volatility in real stock returns. For many European countries, but not for the US, increased volatility of oil prices significantly depresses real stock returns. The contribution of oil price shocks to variability in real stock returns in the USA and most other countries is greater than that of interest rate. An increase in real oil price is associated with a significant increase in the short-term interest rate in the USA and eight out of 13 European countries within one or two months. Counter to findings for the US and for Norway, there is little evidence of asymmetric effects on real stock returns of positive and negative oil price shocks for oil importing European countries.

08/02976 Recent trends and future opportunities in UK bioenergy: maximising biomass penetration in a centralised energy system

Perry, M. and Rosillo-Calle, F. *Biomass and Bioenergy*, 2008, 32, (8), 688–701.

In the past decade or so, the British government policy support for renewable energy (RE) has been at the core of the rapid growth of bioenergy in the UK rather than genuine market forces. Policy support has been through various instruments which are discussed in this paper, with particular attention given to co-firing and transport fuels. The UK energy sector remains dominated by large fossil fuels power plants and this does not facilitate the introduction of RE. One exception is co-firing which in 2005 generated 2.5 TWh. Another area of considerable potential and interest is the use of biofuels (biodiesel and bioethanol) for transport, although current contribution remains still very small (0.18% of total fuel sales in 2005). In 2005, the UK used 1.4 million tonnes of biomass in co-firing, mostly imported, while considerable potential exists for further expansion should policy incentives continue. It is also generally accepted that the UK will have to rely largely on imports if it is to fulfil its 5% minimum biofuel blends agreed for 2010 and 10% in 2015. Both sectors present excellent opportunities for international bioenergy trade, despite the domestic production potential, as demonstrated in this paper. In addition, the forthcoming introduction of carbon and sustainability reporting should incentivise greater reporting along the supply chain, encouraging trade in the most sustainable biofuels.

08/02977 Sectoral trends in global energy use and greenhouse gas emissions

de Ia Rue du Can, S. and Price, L. *Energy Policy*, 2008, 36, (4), 1386–1403.

Integrated assessment models have been used to project both baseline and mitigation greenhouse gas emissions scenarios. Results of these scenarios are typically presented for a number of world regions and end-use sectors, such as industry, transport, and buildings. Analysts interested in particular technologies and policies, however, require more detailed information to understand specific mitigation options in relation to business-as-usual trends. This paper presents sectoral trend for two of the scenarios produced by the Intergovernmental Panel on Climate Change's Special Report on Emissions Scenarios. Global and regional historical trends in energy use and carbon dioxide emissions over the past 30 years are examined and contrasted with projections over the next 30 years. Macro-activity indicators are analysed as well as trends in sectoral energy and carbon demand. This paper also describes a methodology to calculate primary energy and carbon dioxide emissions at the sector level, accounting for the full energy and emissions due to sectoral activities.

08/02978 See inside: the development of a cosmic ray muon imaging system to aid the clean up of the UK's nuclear waste legacy

Stanley, S. J. *et al. Annals of Nuclear Energy*, 2008, 35, (3), 507–517.

In recent years the use of non-intrusive and non-invasive imaging techniques to safely interrogate non-nuclear (industrial) storage vessels or process units has seen a significant increase. The nature of material found within active 'legacy waste' storage vessels and other radiation shielded vessels coupled with the distinct lack of access makes representative sampling or visual inspection of the vessel extremely problematic and in some cases impossible. However, until recently, the radiation shielding which is commonplace on all nuclear sites has rendered existing remote non-intrusive imaging techniques useless. This is due to the limiting penetrative power of X-rays and gamma-rays as well as lack of access for other semi-invasive techniques such as electrical and acoustic imaging. Cosmic ray muon based imaging systems have great potential. This is because muons have very high energies (up to 10^{12} GeV) and therefore, offer a superior penetrative power which provides a means to 'peer through' objects which otherwise would be inaccessible. Such objects may include lead lined silo or vessels as well as various intermediate material transport modules. Because muons only show detectable interactions with high atomic number material they also offer a means to detect the quantity and location of heavy metal elements and their associated compounds. In this work the first attempts at two-dimensional muon attenuation mapping are described. More specifically multiple plane prototype muon detection system has been used to image the resultant attenuation maps for a number of lead phantoms. This opens up possibilities for the collation of muon trajectory data which in turn can be used to track muon events both entering and leaving the object of interest allowing attenuation based image processing. It is believed that future work in this area will serve to significantly improve both the coverage area and the spatial resolution of the system though improved detector technology providing a powerful tool for the rendering of either large or dense objects.

08/02979 Solving economic load dispatch problems in power systems using chaotic and Gaussian particle swarm optimization approaches

dos Santos Coelho, L. and Lee, C.-S. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (5), 297–307.

The objective of the economic dispatch problems (EDPs) of electric power generation is to schedule the committed generating units outputs so as to meet the required load demand at minimum operating cost while satisfying all units and system equality and inequality constraints. Recently, global optimization approaches inspired by swarm intelligence and evolutionary computation approaches have proven to be a potential alternative for the optimization of difficult EDPs. Particle swarm optimization (PSO) is a population-based stochastic algorithm driven by the simulation of a social psychological metaphor instead of the survival of the fittest individual. Inspired by the swarm intelligence and probabilities theories, this work presents the use of combining of PSO, Gaussian probability distribution functions and/or chaotic sequences. In this context, this paper proposes improved PSO approaches for solving EDPs that takes into account non-linear generator features such as ramp-rate limits and prohibited operating zones in the power system operation. The PSO and its variants are validated for two test systems consisting of 15 and 20 thermal generation units. The proposed combined method outperforms other modern metaheuristic optimization techniques reported in the recent literature in solving for the two constrained EDPs case studies.

08/02980 The capacity credit of micro-combined heat and power

Hawkes, A. D. and Leach, M. A. *Energy Policy*, 2008, 36, (4), 1457–1469.

This article is concerned with development of a methodology to determine the capacity credit of micro-combined heat and power (micro-CHP), and application of the method for the UK. Capacity credit is an important parameter in electricity system planning because it measures the amount of conventional generation that would be displaced by an alternative technology. Firstly, a mathematical formulation is presented. Capacity credit is then calculated for three types of micro-CHP units – Stirling engine, internal combustion engine, and fuel cell systems – operating under various control strategies. It is found that low heat-to-power ratio fuel cell technologies achieve the highest capacity credit of approximately 85% for a 1.1 GW penetration when a heat-led control strategy is applied. Higher heat-to-power ratio Stirling engine technology achieves approximately 33% capacity credit for heat-led operation. Low heat-to-power ratio technologies achieve higher capacity credit because they are able to continue operating even when heat demand is relatively low. Capacity credit diminishes as penetration of the technology increases. Overall, the high capacity credit of micro-CHP contributes to the viewpoint that the technology can help meet a number of economic and environmental energy policy aims.

08/02981 The dimensions of the policy debate over transportation energy: the case of hydrogen in the United States

Collantes, G. *Energy Policy*, 2008, 36, (3), 1059–1073.

Environmental and politico-strategic concerns have driven the increase in policy activity related to energy that the United States witnessed in the last few years. The nature of the issues at stake and the level of stakeholder involvement result in a highly complex policy debate. The broad concern of this paper is the study of this energy-policy process and the identification of the main policy issues. Specifically, multivariate analysis is applied to data on a wide variety of stakeholders' policy beliefs and policy preferences to identify the policy dimensions that characterize the debate over energy policy in the United States. The focus is on the policy debate over hydrogen as a transportation fuel, although many results are applicable to the debate over transportation energy at large. The analysis uses a dataset of 502 individuals from 323 different stakeholder organizations obtained via a web-based survey specifically designed for this study.

08/02982 The economy-wide impact of controlling energy consumption in Indonesia: an analysis using a Social Accounting Matrix framework

Hartono, D. and Resosudarmo, B. P. *Energy Policy*, 2008, 36, (4), 1404–1419.

Escalating oil prices and the need to control carbon emissions sound the alarm for Indonesia to reduce or be more efficient in its energy use. Instead of eliminating the fuel oil subsidy to promote better and more efficient use of energy, the Indonesian government seems to be more in favour of restricting energy use by, for example, requiring all hotels, restaurants, night clubs and other business activities to close down by 1 am. Societies need to understand the full consequences of adopting restricting energy use and more efficient energy use strategies toward their incomes. This paper aims to analyse the impact on the economy of energy policies aiming to reduce and to improve the efficiency of energy use, particularly on the income of various household groups. This paper will, first, construct a Social Accounting Matrix for Indonesia with detailed energy sectors and, second, utilize various multiplier analyses to observe and understand the impact of these energy policies.

08/02983 The effect of standards and fuel prices on automobile fuel economy: an international analysis

Clerides, S. and Zachariadis, T. *Energy Economics*, 2008, 30, (5), 2657–2672.

There is an intense debate over whether fuel economy standards or fuel taxation is the more efficient policy instrument to raise fuel economy and reduce CO_2 emissions of cars. The aim of this paper is to analyse the impact of standards and fuel prices on new-car fuel economy with the aid of cross-section time series analysis of data from 18 countries. A dynamic specification of new-car fuel consumption is employed as a function of fuel prices, standards and per capita income. It turns out that standards have induced considerable fuel savings throughout the world, although their welfare impact is not examined here. If standards are not further tightened then retail fuel prices would have to remain at high levels for more than a decade in order to attain similar fuel savings. Finally, without higher fuel prices or tighter standards, one should not expect any marked improvements in fuel economy under 'business as usual' conditions.

08/02984 The potential demand for bioenergy in residential heating applications (bio-heat) in the UK based on a market segment analysis

Jablonski, S. *et al. Biomass and Bioenergy*, 2008, 32, (7), 635–653.

How large is the potential demand for bio-heat in the UK? Whilst most research has focused on the supply of biomass for energy production, an understanding of the potential demand is crucial to the uptake of heat from bioenergy. A systematic framework has been designed utilizing market segmentation techniques to assess the potential demand for biomass heat in the UK. First, the heat market is divided into relevant segments, characterized in terms of their final energy consumption, technological and fuel supply options. Second, the key technical, economic and organizational factors that affect the uptake of bioenergy in each heat segment are identified, classified and then analysed to reveal which could be strong barriers, which could be surmounted easily, and for which bioenergy heat represents an improvement compared to alternatives. The defined framework is applied to the UK residential sector. The authors identify provisionally the most promising market segments for bioenergy heat, and their current levels of energy demand. It is found that, depending on the assumptions, the present potential demand for bio-heat in the UK residential sector ranges between 3% (conservative estimate) and 31% (optimistic estimate) of the total energy consumed in the heat market.

08/02985 The role of spectral response of photosensors in daylight responsive systems

Doulos, L. *et al. Energy and Buildings*, 2008, 40, (4), 588–599.

Lighting control technologies using photosensors have a great potential for energy savings in areas with high levels of daylight. Although the proper application of these controls can exploit this potential, unfortunately, it has been accomplished in a small percentage of new projects. One reason is the difficulty in justification of energy savings, which in turn, is directly linked with the simulation of the behaviour of these lighting controls. The core of these systems is the photosensor, which adjusts the electric light output in proportion to the amount of the daylight that detects, using its spatial and spectral response. The aim of this study is to quantify the impact of photosensor spectral response on its illuminance values, by taking into account various daylight spectra as these are modified due to various types of coloured glazing. Five commercial photosensors were selected and their spectral response was measured. In addition, spectral transmittance of 16 commercial types of glazing was measured as well. Using these data, a set of simulations were performed using three colour channels in a typical office room and the relative differences in illuminance – and thus energy savings – among the photosensors are presented. The results show that differences are significant ranging from 36 to 118%, a fact that can affect the estimated payback period of a lighting control system.

08/02986 The screening and scoping of environmental impact assessment and strategic environmental assessment of carbon capture and storage in the Netherlands

Koorneef, J. *et al. Environmental Impact Assessment Review*, 2008, 28, (6), 392–414.

The environmental impact assessment (EIA) and strategic environmental assessment (SEA) are procedural tools which have as goal to assess and evaluate possible environmental effects of, respectively, a proposed project or policy plan. The goal of this article is to explore possible bottlenecks in applying both the EIA and SEA procedures on carbon capture and storage (CCS) activities in the Netherlands, as experience is currently minimal or lacking. In this study, the authors focus mainly on the institutional and procedural aspects of the screening and scoping phases of both procedures. This is achieved by reviewing EIA and SEA procedures for analogue projects for the three distinctive process steps of a CCS project, namely the power plant with capture, the transport and finally the underground storage of the CO_2. Additionally, EIA and SEA or similar procedures on CCS in other countries are reviewed and the legal framework for the Dutch EIA and SEA is studied. This article shows a concise overview of the EIA and SEA procedure in the Netherlands and the relation between both procedures. Based on the findings, a conceptual taxonomy has been constructed for the scope of both procedures for CCS in the Netherlands. This taxonomy conceptualizes the possible integration of assessing the environmental impacts for tiered levels of decision making. This integration might be needed for first CCS projects as decisions on the strategic (spatial planning) level are currently absent for CCS in the Netherlands. Perpendicular to such integration is the integration of linked activities in the CCS chain and their alternatives, into one procedure. It is argued that it would be beneficial to combine the separate EIA procedures for CCS activities into one procedure or at least provide close linkage between them. This issue should be carefully considered by regulators, competent authorities and project initiators in an early stage to avoid delaying legal procedures in the future. For the same reason also early involvement of public, interested parties and the Netherlands Commission for the Environmental Impact Assessment in the scoping phase of the procedures is desired.

08/02987 Which environmental problems get policy attention? Examining energy and agricultural sector policies in Sweden

Engström, R. *et al. Environmental Impact Assessment Review*, 2008, 28, (4–5), 241–255.

Not all environmental problems get the same level of policy attention. An interesting question is thus why certain aspects receive attention and others do not. This paper studies the level of policy attention given to different environmental aspects in agriculture and energy policy in Sweden and explores empirically some factors that can explain the level of attention. The first step was to explore the link between environmental issue characteristics and the level of policy attention. The level of policy attention was measured through a content analysis of Swedish government bills. The results from the content analysis are clear and stable over the studied time period. In the agriculture sector biodiversity and toxicity are in focus whereas in the energy sector climate change and resources are given the attention. Besides these aspects, the attention is limited. These results were compared with the results from sector-wide environmental assessments of the same sectors. These assessments were based on hybrid input–output analysis and life cycle assessment methodologies. A main finding from the study is that issue importance is a necessary but not a sufficient condition for policy attention. Other explanations are needed to understand which environmental issues get attention in sectoral policy. The assessment showed that while the level of knowledge does not provide an explanation, the presence of strong and well-organised stakeholders within the sector, with an interest in having a certain issue on the agenda, might be decisive for issue attention. Path dependency and limited attention capacity are other important factors.

Energy conservation

08/02988 A high power quality anti-islanding method using effective power variation

Yu, B. *et al. Solar Energy*, 2008, 82, (4), 368–378.

Islanding phenomenon is undesirable because it leads to a safety hazard to utility service personnel and may cause damage to power generation and power supply facilities as a result of unsynchronized reclosure. In order to prevent the phenomenon, various anti-islanding methods have been studied. Until now, frequency or start phase shift methods of inverter current have much attention as active anti-islanding methods, which cause reactive power variation to the utility. However, these methods deteriorate usually the power quality like power factor or harmonic performance. This paper proposes a high power quality active anti-islanding method using effective power variation, which is implemented by periodically increasing/decreasing variation of inverter current magnitude. If it causes the large variation of inverter output voltage after islanding, active frequency drift (AFD) method as a simple anti-islanding method will be injected into the inverter current for a designed period and islanding can be detected. In case of large voltage variation when the grid is connected, AFD method will be removed after the designed period. Unlike most active anti-islanding method deteriorating power quality, the proposed method will have high performance of islanding detection and good power quality. For the verification of the proposed method, simulated results and experimental results in addition to analysis are presented using a 3 kW PV inverter.

08/02989 A new approach to ensure successful implementation of sustainable demand side management (DSM) in South African mines

Pelzer, R. *et al. Energy*, 2008, 33, (8), 1254–1263.

Demand side management (DSM) is seen as a short-term solution to the imminent problem of electricity supply shortages in South Africa. DSM aims to reduce peak loads with immediate results in a short time. The mining sector in South Africa is a large energy user with pumping one of the largest consuming systems. Therefore, DSM potential (load shift) should be investigated on these pumping systems. For sustainable load shift, a system is required that simulates, optimizes and controls the actual on-site situation. As no such equipment that performs all these processes could be found for deep South African mines, it was developed by HVAC International (Pty) Ltd. It is called the real-time energy management system (REMS). With this system, maximum results can be obtained on a sustainable basis. In this study, four similar DSM projects were investigated. These are described as case studies at gold mines in the Free State Province. For each of these studies a different new innovation was implemented. The innovations described include the adaptation of REMS to handle multi-level intricate pump systems, mines without any instrumentation and control infrastructure, as well as three chamber piped feeder systems.

08/02990 A review on buildings energy consumption information

Pérez-Lombard, L. *et al. Energy and Buildings*, 2008, 40, (3), 394–398.

The rapidly growing world energy use has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts (ozone layer depletion, global warming, climate change, etc.). The global contribution from buildings towards energy consumption, both residential and commercial, has steadily increased reaching figures between 20% and 40% in developed countries, and has exceeded the other major sectors: industrial and transportation. Growth in population, increasing demand for building services and comfort levels, together with the rise in time spent inside buildings, assure the upward trend in energy demand will continue in the future. For this reason, energy efficiency in buildings is today a prime objective for energy policy at regional, national and international levels. Among building services, the growth in HVAC systems energy use is particularly significant (50% of building consumption and 20% of total consumption in the USA). Private initiative together with government intervention through the promotion of energy efficiency, new technologies for energy production, limiting energy consumption and raising social awareness on the rational use of energy will be essential to make possible a sustainable energy future.

08/02991 An integrated engineering–econometric analysis of residential balance point temperatures

Dubin, J. A. *Energy Economics*, 2008, 30, (5), 2537–2551.

This paper examines the theoretical and empirical properties of residential balance point temperatures. Heating-degree type measures in energy load temperature models are typically used because heating load should be zero when temperatures are larger than the base (balance point) level. Thermostat setting and the insulation properties of the residential shell determine the balance point temperature. Proper measurement of balance point temperatures is important in selecting the base temperature used in heating and cooling degree measures. The author applies an engineering thermal load model to impute balance point temperatures for residential households in the Puget Sound Energy Washington service territory. The distribution of implied balance point temperatures suggests that heating degree measures base 65 °F inadequately capture the non-linear relationship between load and temperature due to prevalence of low balance point households.

08/02992 Consistent multi-level energy efficiency indicators and their policy implications

Bor, Y. *Energy Economics*, 2008, 30, (5), 2401–2419.

In order to cope with the global warming issue, most of the Asia-Pacific Economic Cooperation economies have made energy conservation policy a top priority in terms of their energy policies. The energy efficiency indicators included in the present paper focus on the micro-foundation aspects. There are basically two types of energy efficiency indicators, namely, the economic-thermodynamic energy efficiency indicators (that use real GDP as the denominator), and the physical-thermodynamic energy efficiency indicators (that are based on the output volume index). While the common definitions and consistent methodology used in the present paper fulfill the IEA pyramid EEI concept, the new methodology in this paper compares the decomposition effects between upstream and downstream industries when aggregating efficiency changes. These decomposition effects can thereby provide valuable explanations for the energy conservation policy needed by energy policy and government administrators.

08/02993 Decision-making in electrical appliance use in the home

Yamamoto, Y. *et al. Energy Policy*, 2008, 36, (5), 1679–1686.

This paper presents the results of a survey as well as an argument from the viewpoint of behavioural economics with the aim of clarifying how consumers make decisions about electrical appliance use in the home. A survey of consumers showed that most have little awareness of the energy efficiency of appliances, the price of the services produced by electrical appliances, or electricity rates. These findings indicate that price does not function as a signal in electricity consumption through electrical appliance use. Rather, it was found that consumer decision-making in electricity consumption is dependent on the characteristics of the particular electrical appliances they use. Additionally, it is argued that the payment system for home electricity consumption plays an important role in decision-making, causing biases due to aspects of human psychology discussed here in terms of satisficing and heuristics, payment decoupling, and budgeting. It was concluded that decision-making about electrical appliance use and electricity consumption in the home is not always rational and is affected both by the particular characteristics of appliances and the payment system for electricity consumption along with human psychology.

08/02994 Development of a cost-effective solar illumination system to bring natural light into the building core

Rosemann, A. *et al. Solar Energy*, 2008, 82, (4), 302–310.

This paper describes a novel and cost-effective way of providing direct sunlight to the core areas of a multi-storey building. In this system, sunlight is collected by a structure, called the solar canopy illumination system, which attaches to the building directly above the windows on each floor. The sunlight is then redirected by the optical components within the canopy and distributed within the building through a series of special-purpose light guides. These guides pipe the sunlight into the building, and also efficiently incorporate electric light sources so that they can provide supplemental lighting as necessary. This system combines several important energy-saving features and uses components that can be low cost in volume manufacturing. As a result, the system has the potential to be truly cost-effective based on the energy savings. The widespread adoption of such a system could substantially reduce energy consumption worldwide which would make a significant contribution toward greenhouse gas mitigation.

08/02995 Disagreement over carbon footprints: a comparison of electric and LPG forklifts

Johnson, E. *Energy Policy*, 2008, 36, (4), 1569–1573.

Carbon footprint is an increasingly popular concept: for labelling, marketing, finance and regulation. In individual cases, carbon footprints can also be contentious, for example in the case of liquefied petroleum gas (LPG) and electric forklifts. Therefore, the fuel carbon footprints of the two were investigated to see if a fair, robust comparison could be made. This investigation yielded two conclusions: (1) definitions will continue to complicate footprint comparisons and (2) fuel carbon footprints of electric and LPG forklifts are, in principle, about equal, while in actual practice, LPG's footprint is smaller than that of electricity. The paper concludes that carbon footprint definitions should be sensible and transparent, but not prescribed.

08/02996 Energy conservation on Nova Scotia farms: baseline energy data

Bailey, J. A. *et al. Energy*, 2008, 33, (7), 1144–1154.

Direct energy use is a small but essential component of the farm greenhouse gas (GHG) budget. Improvements in energy efficiency and renewable energy can help reduce farm operating costs, improve air quality and reduce GHG emission levels. Energy conservation is especially important in Nova Scotia (NS), Canada, where fossil fuels, particularly coal, remain the primary source of electrical generation. Responses from mail surveys were used to establish baseline data on a cross-section of NS farms with respect to direct energy costs and usage to demonstrate differences in farm type and size. A 32% ($N=224$) response rate was achieved. Based on this survey, the average energy bill for a NS farm in 2004 was $11,228, with most (61.7%) of their energy cost attributable to the purchase of petroleum products. Almost all farmers (96.4%) indicated that their energy cost was a primary concern. Farmers identified the operation of vehicles and mobile equipment, as well as lighting and heating as having the greatest energy requirements in their operations. Energy usage varied with farm type and size. NS farms consumed 1.2 petajoules of energy equivalent to 127 kilotonnes of CO_2 with 52.7% of emissions from electricity use in 2004.

08/02997 Energy efficiency improvements in longan drying practice

Tippayawong, N. *et al. Energy*, 2008, 33, (7), 1137–1143.

This paper presents and evaluates methods of improvement of energy utilization and reduction of energy cost in conventional unpeeled longan drying. Existing dryers were modified into a new dryer arrangement. Performance in terms of specific energy utilization, thermal efficiency and operating cost indices for both traditional and new designs was evaluated. Results showed that the modified dryer yielded an average thermal efficiency of 0.35, compared to 0.29 for the existing dryer. For the same mass of dried longan produced, specific energy utilization and fuel cost were reduced by more than 16% and 80%, respectively. The improvement was attributed to fuel switching from liquefied petroleum gas to wood, heat recovery via hot air recirculation, better temperature and humidity control, and thermal insulation. The new dryer with improved design and better energy efficiency was estimated to have payback period less than 3 years.

08/02998 Energy efficient design strategies in the hot dry area of Turkey

Manioğlu, G. and Yilmaz, Z. *Building and Environment*, 2008, 43, (7), 1301–1309.

Climate has a major effect on the performance of the building and its energy consumption. This study is based on a student workshop, which has been carried out for a hot dry area of Turkey. The study first aims to show the similarities and the differences of the traditional housing principles from the climate responsive design point of view. Secondly, it aims to put forward the basic principles and their meaningful changes in usage that can be used in the sustainable housing designs of the future. In this study, design strategies in Mardin, a town situated in the hot-dry area of the south-eastern part of Turkey, were examined and modern and traditional houses were evaluated in terms of design criteria such as, selection of the area, distance between buildings, orientation, building envelope and building form. In this paper, a simplified thermal evaluation and comparison of a traditional house with a contemporary house have been given by using only data derived from the measurements and this evaluation has been done via both measurements and questionnaires which are carried out for 100 buildings.

08/02999 Energy impact of indoor environmental policy for air-conditioned offices of Hong Kong

Wong, L. T. *Energy Policy*, 2008, 36, (2), 714–721.

Air-conditioned office buildings are one of the biggest energy consumers of electricity in developed cities in the subtropical climate regions. A good energy policy for the indoor environment should respond to both the needs of energy conservation and the needs for a desirable indoor healthy environment with a reduction in carbon dioxide (CO_2) generation. This study evaluates energy implications and the corresponding CO_2 generation of some indoor environmental policies for air-conditioned office buildings in the subtropical climate. In particular, the thermal energy consumption in an air-conditioned office building was evaluated by the heat gains through the building fabric, the transport of outdoor fresh air for ventilation, and the heat generated by the occupant and equipment in the space. With the Monte-Carlo sampling technique and the parameters from the existing office building stocks of Hong Kong, the energy consumption profiles of air-conditioned office buildings in Hong Kong were evaluated. Energy consumption profiles were simulated for certain indoor environmental quality (IEQ) policies on indoor air temperature and CO_2 concentration settings in the offices, with other building parameters remaining unchanged. The impact assessment and the regression models described in this study may be useful for evaluation of energy performances of IEQ policies. They will also be useful for the promotion of energy-saving measures in air-conditioned office buildings in Hong Kong. This study presented a useful source of references for policymakers, building professionals and end users to quantify the energy and environmental impacts due to an IEQ policy for air-conditioned office buildings.

08/03000 Evaluating the scope for energy-efficiency improvements in the public sector: benchmarking NHSScotland's smaller health buildings

Murray, J. *et al. Energy Policy*, 2008, 36, (3), 1236–1242.

The National Health Service in Scotland (NHS Scotland) has, in recent years, done much to reduce energy consumption in its major healthcare buildings (hospitals). On average, a reduction of 2% per year has been achieved since 2000, based on hospital buildings. However, there had been little or no attention paid to smaller premises such as health centres, clinics, dentists, etc. Such smaller healthcare buildings in Scotland constitute 29% of the total treated floor area of all NHS Scotland buildings and, therefore, may contribute a similar percentage of carbon and other emissions to the environment. By concentrating on a sample of local health centres in Scotland, this paper outlines the creation of an energy benchmark target, which is part of a wider research project to investigate the environmental impacts of small healthcare buildings in Scotland and the scope for improvements. It was found that energy consumption varied widely between different centres but this variation could not be linked to building style, floor area or volume. Overall, it was found that a benchmark of $0.2\,\mathrm{GJ/m^3}$ would be challenging, but realistic.

08/03001 Feebates promoting energy-efficient cars: design options to address more consumers and possible counteracting effects

Peters, A. *et al. Energy Policy*, 2008, 36, (4), 1355–1365.

An increasing number of countries have implemented or are evaluating feebate systems in order to reduce energy consumption of new vehicle registrations. The authors distinguish between absolute feebates based strictly on a vehicle's energy consumption and relative feebates normalizing energy consumption by a given car utility. This paper analyses whether absolute or relative feebates encourage more consumers to change to vehicles with lower energy consumption. An analysis of all car models on sale at the end of 2005 is combined with with survey data from 326 potential new car buyers. Analysis of the car fleet with regard to behavioural changes assumed as realistic shows that relative systems succeed better in offering more consumer groups cars that are eligible for incentives. Survey results suggest that consumers show some, but limited, willingness to change behaviour to obtain an incentive. However, a relative system potentially allows people to switch to cars with higher relative efficiency without actually lowering absolute CO_2 emissions. This inherent dilemma of simultaneously addressing more consumers and limiting counteracting effects is discussed. In order to find the optimal trade-off, it is suggested that assessing different parameters operationalizing vehicle utility by means of micro-simulation with detailed car fleet and differentiated consumer segments.

08/03002 Free convection heat transfer inside vertical and inclined elliptic tubes with different axis ratio and different inclination and orientation angles

Moawed, M. and Ibrahim, E. *Energy Conversion and Management*, 2008, 49, (4), 587–595.

Experimental investigation of free convection heat transfer from the inside surface of vertical and inclined elliptic tubes of different axis ratios (AR), different orientation angles and different inclination angles with a uniformly heated surface are presented. The AR is changed from 1.5 to 3.5, the inclination angle is changed from 15° to 75° and the orientation angle is changed from 0° to 90°. The experiments covered a range of Rayleigh number, Ra from 6.85×10^5 to 1.3×10^8. The local and average heat transfer coefficients and Nusselt numbers are estimated for different ARs and different orientation angles at different Rayleigh numbers. The experimental results showed that the AR has a significant effect on the local and average heat transfer coefficients. The local Nusselt number (Nu) increases with the increase of axial distance from the lower end of the elliptic tube until a maximum value is reached near the top of the elliptic tube, and then, the Nu gradually decreases. Also, the local Nu increases with the increase of α, ϕ and AR at the same axial distance. The average Nu increases with the increase of orientation angle, inclination angle and AR at a constant Ra. Correlations of the average Nusselt number for free convection inside vertical and inclined elliptic tubes with the orientation angles (α), inclination angles (ϕ) and AR are presented.

08/03003 Fuel conserving (and using) production functions

Saunders, H. D. *Energy Economics*, 2008, 30, (5), 2184–2235.

This article compares eight production/cost functions used or potentially useful for exploring how energy efficiency gains affect energy consumption. It is shown that the practitioner's choice of function can inadvertently pre-determine results, and make recommendations as to which functions are flexible enough to prevent this. Also shown are pre-selected factor substitution elasticities can similarly pre-determine results. To aid the comparison, the authors decompose the energy consumption 'rebound' effect into intensity and output/income effects, which also delivers insight into the mechanisms of rebound. It is concluded that by recommending practitioners restrict themselves to either the Gallant (Fourier) or the generalized Leontief/symmetric generalized Barnett cost functions as being sufficiently 'rebound flexible.' The translog cost function may be suitable given certain conditions and a particular form of the CES (Solow) function is a possible, but problematic, candidate. Along the way, the article provides a general methodology for similarly examining any arbitrarily-defined constant returns to scale production or cost function.

08/03004 Improved performance of Pd electrocatalyst supported on ultrahigh surface area hollow carbon spheres for direct alcohol fuel cells

Hu, F. P. *et al. Journal of Power Sources*, 2008, 177, (1), 61–66.

Ultrahigh surface area hollow carbon spheres (HCSs) with open micropores and nanochannels have been prepared by combined methods of hydrothermal and intermittent microwave heating (IMH) for the first time. It is found that the addition of poly(ethylene glycol)-block-poly(propylene glycol)-block-poly(ethylene glycol) (P123) leads to a large BET surface area of $1249.3\,m^2\,g^{-1}$. The catalytic activity of Pd supported on HCS is over 3 times higher than that on Pd supported on commercial Vulcan XC-72 carbon at the same Pd loadings. It is proven that the higher catalytic activity is contributed from the formation of the high electrochemical active surface area, which is due to the hollow carbon structure with open micropores and nanochannels.

08/03005 Lighting energy savings in offices using different control systems and their real consumption

Roisin, B. *et al. Energy and Buildings*, 2008, 40, (4), 514–523.

This paper compares the potential of lighting energy savings in office rooms by using different control systems, for three locations in Europe and the four main orientations. The method is based on DAYSIM simulations to perform daylight calculations, on laboratory measurement to evaluate precise system energy consumptions and on the implementation of a new algorithm to simulate a close-loop daylight dimming system. It appears that the control of the electrical power in function of daylight leads to very high savings; they slightly depend on the room orientation and the location. Savings vary from 45 to 61%. The performances of an occupancy sensor are also tested. Threshold values of occupancy rate for which daylight dimming leads to higher gains than an occupancy control system vary between 27 and 44% depending on location and orientation. The measurements of the energy consumption of the sensors and detectors also permit to conclude that systems with embedded DALI-compatible ballast controllers should be abandoned in favour of a centralized DALI-compatible ballast controller or embedded analogue systems.

08/03006 Natural ventilation of indoor spaces while minimizing heat losses: theoretical and experimental investigation

Hatzidimoula, E. and Poulios, K. *Energy and Buildings*, 2008, 40, (4), 621–626.

Limiting heat losses during ventilation of indoor building spaces has become a basic aim for architects, particularly since the oil crisis of 1970. Much experience has been gained in terms of ventilation of indoor spaces. Nevertheless, due to the complex applications, attempts to create a theoretical base for solving the problems related to the issue are limited, especially determining the minimum ventilation period required within a designated space. In this paper, this matter was approached, both theoretically and experimentally. The conclusion reached was that controlled ventilation of spaces through vent holes that successively open and close at regular time intervals can limit the excessive circulation of air masses, which in turn limits heat losses.

08/03007 Numerical investigation on thermal performance and correlations of double skin façade with buoyancy-driven airflow

Pappas, A. and Zhai, Z. *Energy and Buildings*, 2008, 40, (4), 466–475.

This paper briefly reviews the primary parameters for a double skin façade (DSF) design. The research presents an integrated and iterative modelling process for analysing the thermal performance of DSF cavities with buoyancy-driven airflow by using a building energy simulation program (BESP) along with a computational fluid dynamics (CFD) package. A typical DSF cavity model has been established and simulated. The model and the modelling process have been calibrated and validated against the experimental data. The validated model was used to develop correlations that can be implemented in a BESP, allowing users to take advantage of the accuracy gained from CFD simulations without the required computation time. Correlations were developed for airflow rate through cavity, average and peak cavity air temperature, cavity air pressure, and interior convection coefficient. The correlations are valuable for 'back of the envelope' calculation and for examining accuracy of zonal-model-based energy and airflow simulation programs.

08/03008 Quick evaluation of the annual heliostat field efficiency

Collado, F. J. *Solar Energy*, 2008, 82, (4), 379–384.

The recent world-wide interest in solar power towers justifies the presentation of a simplified model that allows quick evaluations of the annual overall energy collected by a surrounding heliostat field, which is sent to the electric power generating system (EPGS). The model is the combination of an analytical model of the flux density produced by a heliostat from Zaragoza University, an optimized mirror density distribution developed by University of Houston for the Solar One project and molten salt receiver efficiencies measured during the Solar Two project. The abilities of the model are successfully compared against the scarce open data about the next Solar Tres demonstration plant-a 15 MWe solar tower with molten salts storage. This simplified model could be valid for rather preliminary optimizations, although it should not substitute much more accurate discrete evaluations that manage thousands of individual heliostats with their actual shadowing and blockings, performed every few minutes using actual meteorological data.

08/03009 The Energy Concept Adviser – a tool to improve energy efficiency in educational buildings

Erhorn, H. *et al. Energy and Buildings*, 2008, 40, (4), 419–428.

The main goal of the International Energy Agency ECBCS Annex 36 is to provide the educational building decision-makers with sufficient data, information and tools to improve their learning and teaching environments by improving the energy efficiency of their buildings. This is the background for the development of an Energy Concept Adviser (ECA) for energy and financial retrofit measures that is useful during the planning and concept development phases for educational buildings. On the one hand to help the owner to find the most efficient energy saving measures and on the other hand to prevent that exaggerated expectations are raised. The ECA should be applicable during the entire retrofitting phase to ensure that both the calculated energy savings and financial success will be achieved after retrofitting. This paper describes a tool that assists educational building decision-makers while the construction project is still in the design phase. This tool will improve new or existing buildings through the identification and calculation of potential energy savings. The ECA includes suggestions of energy systems to use and potential design concepts to be considered during the design phase. During the past 6 years, data have been gathered from all the 10 participating countries of the Annex 36. This electronic internet-based tool incorporates an interactive source book of information, which includes design concepts, design advise, design and decision programs, and case studies. The tool has been translated into several languages.

08/03010 The impact of DOE building technology energy efficiency programs on U.S. employment, income, and investment

Scott, M. J. *et al. Energy Economics*, 2008, 30, (5), 2283–2301.

The US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) analyses the macroeconomic impacts of its programs that are designed to increase the energy efficiency of the US residential and commercial building stock. The analysis is conducted using the Impact of Sector Energy Technologies (ImSET) model, a special-purpose 188-sector input–output model of the US economy designed specifically to evaluate the impacts of energy efficiency investments and saving. For the analysis described in the paper, ImSET was amended to provide estimates of sector-by-sector capital requirements and investment. In the scenario of the Fiscal Year (FY) 2005 building technologies (BT) program, the technologies and building practices being developed and promoted by the BT program have the potential to save about 2.9×10^{15} Btu in buildings by the year 2030, about 27% of the expected growth in building energy consumption by the year 2030. The analysis reported in the paper finds that, by the year 2030, these savings have the potential to increase employment by up to 446,000 jobs, increase wage income by $7.8 billion, reduce needs for capital stock in the energy sector and closely related supporting industries by about $207 billion (and the corresponding annual level of investment by $13 billion), and create net capital savings that are available to grow the nation's future economy.

08/03011 The impact of indoor thermal conditions, system controls and building types on the building energy demand

Corgnati, S. P. *et al. Energy and Buildings*, 2008, 40, (4), 627–636.

It is possible to evaluate the energy demand as well as the parameters related to indoor thermal comfort through building energy simulation tools. Since energy demand for heating and cooling is directly affected by the required level of thermal comfort, the investigation of the mutual relationship between thermal comfort and energy demand (and therefore operating costs) is of the foremost importance both to define the benchmarks for energy service contracts and to calibrate the energy labeling according to European Directive 2002/92/CE. The connection between indoor thermal comfort conditions and energy demand for both heating and cooling has been analysed in this work with reference to a set of validation tests (office buildings) derived from a European draft standard. Once a range of required acceptable indoor operative temperatures had been fixed in accordance with Fanger's theory (e.g. $-0.5 < \text{PMV} < -0.5$), the effective hourly comfort conditions and the energy consumptions were estimated through dynamic simulations. The same approach was then used to quantify the energy demand when the range of acceptable indoor operative temperatures was fixed in accordance with de Dear's adaptive comfort theory.

08/03012 The selection of effective retrofit scenarios for panel houses in urban neighborhoods based on expected energy savings and increase in market value: the Vilnius case

Zavadskas, E. *et al. Energy and Buildings*, 2008, 40, (4), 573–587.

Some of the problems associated with assessing the retrofit effectiveness of apartment buildings in urban areas are considered. The retrofit of houses should be followed by the amelioration of their surroundings. The priority order of districts to be renovated depends on the condition of the buildings in a district and on strategic urban development programmes. In order to determine the profitability of investments in housing retrofit, a number of retrofit scenarios should be developed. The authors of this paper offer a new approach to determining the retrofit effectiveness of houses based both on expected energy savings and the increase in market value of renovated buildings. In line with the proposed approach, retrofit scenarios for apartment buildings in Vilnius were developed, i.e. retrofit investment packages for various districts were prepared and arranged in the priority order for their application according to the method of geographical analysis suggested by the authors.

08/03013 Theoretical/experimental comparison of heat flux reduction in roofs achieved through the use of reflective thermal insulators

Michels, C. *et al. Energy and Buildings*, 2008, 40, (4), 438–444.

In tropical countries, the greatest thermal gain occurs through the roof of a house. In Brazil, the use of an asbestos-cement roof without a ceiling is very common. Thus, there is intense heat transfer to the internal environment, which may cause thermal discomfort to the inhabitants. One way to reduce the heat flux is the use of radiant barriers, which reduce the heat flux through radiation. The use of this type of barrier in Brazil began in the mid-1990s and since then it has become popular for the thermal insulation of building roofs. However, there is a drawback regarding the experimental methods for the evaluation of the energy efficiency of these sheets. Many manufacturers show only the thermal conductivity, or give sparse information on the percentage reduction in radiated heat. There is currently no Brazilian normalization regarding the effective reductions in heat due to the use of these sheets. This study presents a compact apparatus for the determination of the efficiency of insulation sheets based on the use of heat flux transducers. Also, two models using thermal resistances that give simple correlations of great usefulness are presented. The sensitivity of the efficiency in relation to the several variables involved can be verified by exploring these correlations algebraically. Test results for different types of insulation sheets are reported and compared with the theoretical models.

08/03014 Towards a low-carbon future in China's building sector – a review of energy and climate models forecast

Li, J. *Energy Policy*, 2008, 36, (5), 1736–1747.

This article investigates the potentials of energy saving and greenhouse gases emission mitigation offered by implementation of building energy efficiency policies in China. An overview of existing literature regarding long-term energy-demand and carbon dioxide (CO_2) emission forecast scenarios is presented. Energy consumption in buildings could be reduced by 100–300 million tons of oil equivalent (mtoe) in 2030 compared with the business-as-usual (BAU) scenario, which means that 600–700 million metric tons of CO_2 emissions could be saved by implementing appropriate energy policies within an adapted institutional framework. The main energy-saving potentials in buildings can be achieved by improving a building's thermal performance and district heating system efficiency. The analyses also reveal that the energy interchange systems are effective especially in the early stage of penetration. the analysis on the reviewed models suggests that more ambitious efficiency improvement policies in both supply- and demand-side as well as the carbon price should be taken into account in the policy scenarios to address drastic reduction of CO_2 emission in the building sector to ensure climate security over the next decades.

17 ENERGY CONVERSION AND RECYCLING

08/03015 A review of processes and technologies for the recycling of lithium-ion secondary batteries

Xu, J. *et al. Journal of Power Sources*, 2008, 177, (2), 512–527.

The purpose of this paper is to review the current status of the recycling technologies of spent lithium-ion secondary batteries. It introduced the structure and components of the lithium-ion secondary batteries, summarized all kinds of single recycling processes from spent lithium-ion secondary batteries and presented some examples of typical combined recycling processes. Also, the problems and prospect of the studies of their recycling technologies have been put forward.

08/03016 Description, applications and numerical modelling of bubbling fluidized bed combustion in waste-to-energy plants

Ravelli, S. *et al. Progress in Energy and Combustion Science*, 2008, 34, (2), 224–253.

The use of the fluidized bed combustor (FBC) has increased. It began in the twentieth century as coal combustion and gasification, which then developed into catalytic reactions. Only recently, the application field has been extended to the incineration of biomass and pre-treated waste, for either power generation or waste disposal. The success of fluidized bed combustion is due to high combustion efficiency, great flexibility when it comes to the heating value of the fuel and reduction in pollutants emitted with the flue gas. The purpose of this paper is to extend the computational fluid dynamics (CFD) modelling, which has recently proved to be an effective means of analysis and optimization of energy-conversion processes, even to fluidized bed combustion of refuse-derived fuel (RDF). The increase in computer power over recent years has made this goal attainable. This overview is divided into three main parts. In the first one, after a brief introduction to the fluidized bed hydrodynamics, the phenomena taking place during fluidized bed combustion of solid fuels are explained, with particular interest in drying, devolatilization and char oxidation. Differences in combustion between conventional and alternative fuels are highlighted so as to fully characterize the RDF behaviour in the bed. In the second part, a review of the state of the art of combustion modelling is presented: not only one-dimensional but also multi-dimensional models, applied to the fluidized bed and conventional combustors, are analysed in order to emphasize what has already been done and what remains to be done. From the investigation it emerges that multi-dimensional models of fluidized bed furnaces are still lacking in literature: up to now, several bed hydrodynamics models have been achieved but none of them takes chemical reactions into account. In the last section, a numerical model of a bubbling FBC fed by RDF is presented. The combustor is divided into two regions: the bed and the freeboard. The calculation of mass and energy fluxes entering from the bed into the freeboard provides the boundary conditions for the subsequent CFD analysis. The freeboard model, implemented by means of the commercial code FLUENT 6.1, is mainly concerned with employing the two-mixture-fraction-pdf approach to track both the gases coming from the bed and the solid fuel particles that do not burn in the bed but above it. The excess air is injected through four series of nozzles; furthermore, the heat transfer between the flue gases and the internals is taken into account. The freeboard operation was simulated consistent with two conditions representing the combustor minimum and maximum load. The comparison between the predicted and the experimental data are in agreement: the reliability of the model results proves that CFD modelling is a powerful method to give insight into the behaviour of a full-scale FBC fed by a non-conventional fuel. The minimum load condition is found to reduce combustion efficiency and heat transfer from the flue gas to the boiler tubes.

08/03017 Energy and environmental analysis of an innovative system based on municipal solid waste (MSW) pyrolysis and combined cycle

Baggio, P. *et al. Applied Thermal Engineering*, 2008, 28, (2–3), 136–144.

This paper presents the energy and the environmental impact analysis of an innovative system based on the pyrolysis of MSW which produces solid (char), liquid (tar) and gas (syngas) fuels used in a combined cycle for electric power generation. The syngas, after filtration and compression, feeds two gas turbines. In turn, the exhaust from the gas turbines, after post-combustion with char and tar, drives a steam turbine power plant. Before being discharged, the flue gas is processed in a selective catalytic reduction unit to reduce CO, VOC and NO_x content and is filtered to remove particulate matter. This innovative approach to energy recovery from MSW combines high energy efficiency with a low level of polluting emissions. The estimated global efficiency of the plant, referred to the LHV of the MSW, is around 28–30%, a much higher value than ordinarily obtained in traditional waste incineration plants. The environmental analysis includes a study of the polluting emissions and the simulation of their concentration in the area surrounding the plant: the emissions of the plant have a negligible influence on the original polluting levels of the settlement area.

08/03018 Optimisation of environmental gas cleaning routes for solid wastes cogeneration systems Part I – analysis of waste incineration steam cycle

Holanda, M. R. *et al. Energy Conversion and Management*, 2008, 49, (4), 791–803.

Research of advanced technologies for energy generation contemplates a series of alternatives that are introduced both in the investigation of new energy sources and in the improvement and/or development of new components and systems. Even though significant reductions are observed in the amount of emissions, the proposed alternatives require the use of exhaust gases cleaning systems. The results of environmental analyses based on two configurations proposed for urban waste incineration are presented in this paper; the annexation of integer (Boolean) variables to the environomic model makes it possible to define the best gas cleaning routes based on exergetic cost minimization criteria. In this first part, the results for steam cogeneration system analysis associated with the incineration of municipal solid wastes is presented.

08/03019 Optimisation of environmental gas cleaning routes for solid wastes cogeneration systems. Part II – analysis of waste incineration combined gas/steam cycle

Holanda, M. R. *et al. Energy Conversion and Management*, 2008, 49, (4), 804–811.

In the first paper of this paper (Part I), conditions were presented for the gas cleaning technological route for environomic optimization of a cogeneration system based in a thermal cycle with municipal solid waste incineration. In this second part, an environomic analysis is presented of a cogeneration system comprising a combined cycle composed of a gas cycle burning natural gas with a heat recovery steam generator with no supplementary burning and a steam cycle burning municipal solid wastes to which will be added a pure back pressure steam turbine (another one) of pure condensation. This analysis aims to select, concerning some scenarios, the best atmospheric pollutant emission control routes according to the investment cost minimization, operation and social damage criteria. In this study, a comparison is also performed with the results obtained in the case study presented in part I.

08/03020 Production of liquid fuels and chemicals from pyrolysis of Bangladeshi bicycle/rickshaw tire wastes

Islam, M. R. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 96–109.

Tyre wastes in the form of used bicycle/rickshaw tyres available in Bangladesh were pyrolysed in a fixed-bed fire-tube heating reactor under different pyrolysis conditions to determine the role of final temperature, sweeping gas flow rate and feed size on the product yields and liquid product composition. Final temperature range studied was between 375 and 575 °C and the highest liquid product yield was obtained at 475 °C. Liquid products obtained under the most suitable conditions were characterized by elemental analyses, FT-IR, ^{1}H NMR and GC–MS techniques. The results show that it is possible to obtain liquid products that are comparable to petroleum fuels and valuable chemical feedstock from bicycle/rickshaw tyre wastes if the pyrolysis conditions are chosen accordingly.

08/03021 The development of multi-objective optimization model for excess bagasse utilization: a case study for Thailand

Buddadee, B. *et al. Environmental Impact Assessment Review*, 2008, 28, (6), 380–391.

In this paper, a multi-objective optimization model is proposed as a tool to assist in deciding for the proper utilization scheme of excess bagasse produced in sugarcane industry. Two major scenarios for excess bagasse utilization are considered in the optimization. The first scenario is the typical situation when excess bagasse is used for the onsite electricity production. In case of the second scenario, excess bagasse is processed for the offsite ethanol production. Then the ethanol is blended with an octane rating of 91 gasoline by a portion of 10% and 90% by volume respectively and the mixture is used as alternative fuel for gasoline vehicles in Thailand. The model proposed in this paper called ‘Environmental System Optimization’ comprises the life cycle impact assessment of global warming potential (GWP) and the associated cost followed by the multi-objective optimization which facilitates in finding out the optimal proportion of the excess bagasse processed in each scenario. Basic mathematical expressions for indicating the GWP and cost of the entire process of excess bagasse utilization are taken into account in the model formulation and optimization. The outcome of this study is the methodology developed for decision-making concerning the excess bagasse utilization available in Thailand in view of the GWP and economic effects. A demonstration example is presented to illustrate the advantage of the methodology which may be used by the policy maker. The methodology developed is successfully performed to satisfy both environmental and economic objectives over the whole life cycle of the system. It is shown in the demonstration example that the first scenario results in positive GWP while the second scenario results in negative GWP. The combination of these two scenario results in positive or negative GWP depending on the preference of the weighting given to each objective. The results on economics of all scenarios show the satisfied outcomes.

08/03022 Thermal comfort analysis of a low temperature waste energy recovery system: SIECHP

Martín, R. H. *et al. Energy and Buildings*, 2008, 40, (4), 561–572.

The use of a recovery device is justified in terms of energy savings and environmental concerns. But it is clear that the use of a recovery system also has to lead to controlling indoor environmental quality, nowadays a priority concern. In this article, experimental research has been carried out whose aim is to study the thermal comfort provided by a combined recovery equipment (SIECHP), consisting of a ceramic semi-indirect evaporative cooler and a heat pipe device to recover energy at low temperature in air-conditioning systems. To characterize this device empirically in terms of thermal comfort, Fanger’s predicted mean vote, draught rate, and vertical air temperature difference were used in this study as the TC criteria.

08/03023 Wastewater recycling in laundries – from pilot to large-scale plant

Hoinkis, J. and Panten, V. *Chemical Engineering and Processing: Process Intensification*, 2008, 47, (7), 1159–1164.

A new, innovative wastewater recycling process for industrial laundries has been developed through cooperation between Textil-Service Klingelmeyer (a medium-size laundry in Darmstadt, Germany) and the University of Applied Sciences in Karlsruhe, Germany. The project ‘laundry innovative wastewater recycling technology – LIWATEC’ was sponsored by the European Community in its LIFE-Environment programme. The purpose of the LIWATEC project was to design and start up a new, innovative, integrated process using membrane technology for wastewater reuse on a large scale in the Klingelmeyer laundry. The large scale plant was designed for wastewater treatment capacity of 200 m^3/day. This integrated process has been successfully tested for 5 years in the form of two pilot plants at the laundry in Darmstadt and at the University of Karlsruhe (capacities: 10 m^3/day and <1 m^3/day). The pilot plant data provided a scale up basis for designing the large plant. This paper gives a summary of the pilot plant data in comparison with the initial results of the large-scale unit, which went into operation in June 2006. The integrated process comprises a membrane bioreactor (MBR) with submerged plate and frame microfiltration membranes as the principal cleaning unit. The results of the pilot agree with those of the large-scale plant. The chemical oxygen demand removal efficiency was around 90%; the average flux was approximately 14 L/m^2 h. The MBR permeate provides a water quality that can be used as washing water since it fully meets the requirements of the washing process. Part of the MBR permeate is subsequently treated by reverse osmosis filtration using spiral wound modules in order to remove salts. The average flux of the RO unit is 25–30 L/m^2 h at around 16 bar. The salt retention rate exceeds 99%. The high quality of the reverse osmosis permeate meets the demands of the rinsing processes. In general, up to 90% of total wastewater can be reused. Moreover, it is an easy-handling and cost-efficient wastewater recycling process that could be adapted to different types of laundries due to its modular structure.